3.3 RAD-RS485-IFS modules

For some distributed systems, or networks with very large I/O counts, the master wireless device can be expanded with RAD-RS485-IFS modules. I/O extension modules in the wireless network can be mapped to I/O extension modules connected to RAD-RS485-IFS modules. This is only supported in Wire In/Wire Out mode.

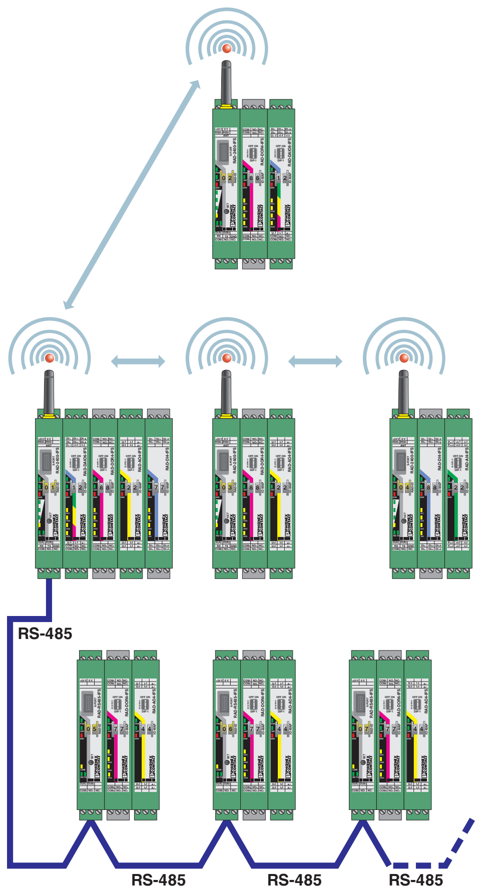


Figure 3-1 Typical RS-485 installation

4 Installation

4.1 Wireless module structure

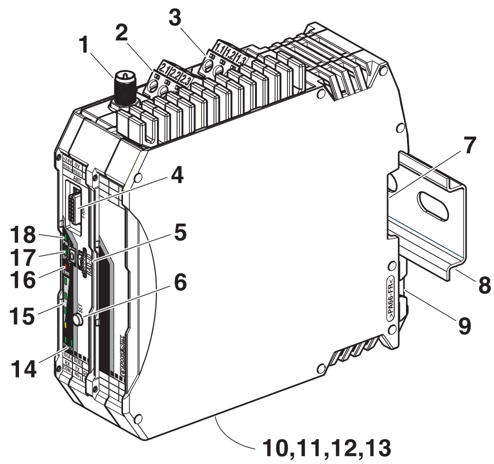


Figure 4-1 RAD-900-IFS structure

Item	Designation
1	RSMA antenna connection (socket)
2	Test output RSSI (0...3 V DC) for evaluation of the wireless signal strength
3	Device supply (+24 V DC, 0 V)
4	12-pos. programming interface (S-PORT)
5	RAD ID address setting via thumbwheel
6	SET button
7	Connection option for TBUS DIN rail connector
8	DIN rail
9	DIN rail release latch
10	Connection terminal block RS-485 interface
11	Connection terminal block RS-232 interface
12	Relay output with PDT contact (floating)
13	9-pos. D-SUB connector (RS-232 interface)
14	RS-232/485 serial interface status LED (RX/TX)
15	LED bar graph for displaying the wireless signal strength
16	ERR status LED, red (communication error)
17	DAT status LED, green (BUS communication)
18	PWR status LED, green (supply voltage)

4.2 Basic circuit diagram

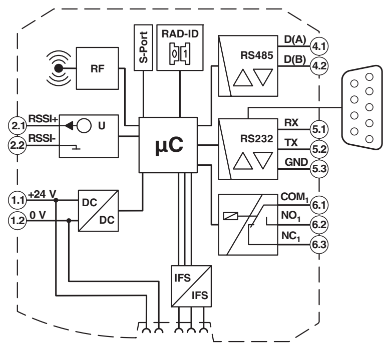


Figure 4-2 Basic circuit diagram of the RAD-900-IFS

4.3 Mounting/removal

You can connect up to 32 different I/O extension modules to each wireless module via the DIN rail connector. Data is transmitted and power is supplied to the I/O extension modules via the bus foot.

When using the device in a connection station, use the supplied 17.5 mm wide DIN rail connector. Only use the DIN rail connector in connection with 24 V DC devices.

Mount the wireless module to the left and the I/O extension modules **exclusively to the right** of the wireless module.

The individual extension modules can be arranged in any order.

Figure 4-3 Radioline connection station with up to 32 I/O extension modules

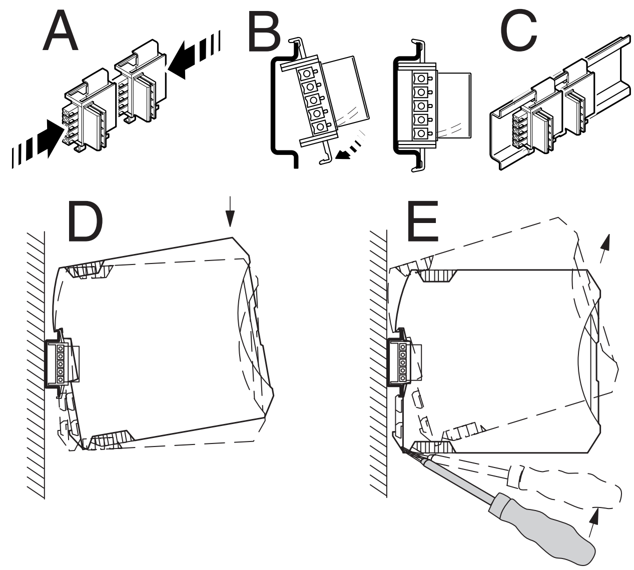


Figure 4-4 Mounting and removal

To mount a connection station with DIN rail connectors, proceed as follows:

1. Connect the DIN rail connectors together for a connection station.
2. Push the connected DIN rail connectors onto the DIN rail.
3. Place the device onto the DIN rail from above (see Figure 4-4, D). Make sure that the device and DIN rail connector are aligned correctly.
4. Holding the device by the housing cover, carefully push the device towards the mounting surface so that the device bus connector is fixed securely on the DIN rail connector.
5. Once the snap-on foot snaps onto the DIN rail, check that it is fixed securely. The device is only mechanically secured via the DIN rail.
6. Connect the desired number of I/O extension modules to the wireless module via the DIN rail connector.

Device replacement is also possible during operation when outside the hazardous area.

Removal

1. Use a suitable screwdriver to release the locking mechanism on the snap-on foot of the device (see Figure 4-4, E).
2. Hold onto the device by the housing cover and carefully tilt it upwards.
3. Carefully lift the device off the DIN rail connector and the DIN rail.

4.4 Connecting wires

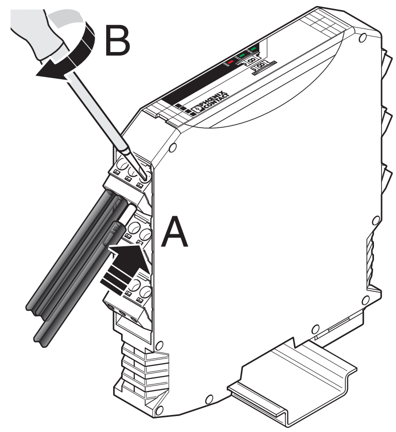


Figure 4-5 Connecting wires

> For easy installation, it is also possible to pull out the screw terminal block from the device and to re-insert it after having connected the wires.

1. Crimp ferrules to the wires. Permissible cable cross section: 0.2 mm^2 ... 2.5 mm^2
2. Insert the wire with ferrule into the corresponding connection terminal block.
3. Use a screwdriver to tighten the screw in the opening above the connection terminal block. Tightening torque: 0.6 Nm

4.5 Connecting the power supply

Via screw terminal blocks

Connect a DC voltage source (10.8 V ... 30.5 V DC) to the wireless module. The nominal voltage is 24 V DC. Supply voltage to the device via the terminals 1.1 (24 V) and 1.2 (0 V). In the case of a connection station, it is sufficient to supply the first device in the group.

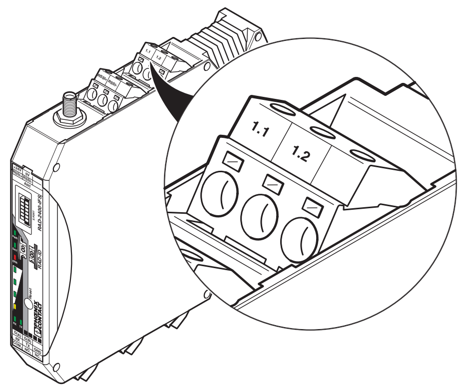


Figure 4-6 Connecting the power supply

In order to prevent damage to the wireless module, we recommend the installation of a surge arrester. Wiring between the surge arrester and the wireless module should be as short as possible. Please also observe the manufacturer's specifications.

4.6 Serial interfaces

The RAD-900-IFS wireless module has one RS-232 interface and one RS-485 2-wire interface. Connect the I/O device to the wireless module via the corresponding serial interface.

> Both serial interfaces are deactivated by default. Activate and configure the RS-232 or RS-485 interface using the PSI-CONF software (from page 38 onwards).
>
> You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.

4.6.1 Shielding of the RS-485 bus cable

Connect the shield of the RS-485 bus cable correctly via an external shield connection clamp.

NOTE: Damage to the interface
If the shield has been incorrectly connected, permanent, external disturbing pulses may damage the interface.

Observe the polarity of the RS-485 2-wire cable and ensure that the shield is connected correctly.

Choose the type of shield connection depending on the interferences to be expected:

- Firstly, connect the shield on one side. This suppresses electrical fields.
- To suppress disturbances caused by alternating magnetic fields, connect the shield on both sides. When doing so, the ground loops must be taken into account. Galvanic disturbances along the reference potential can interfere with the useful signal, and the shielding effect is reduced.
- If several devices are connected to a single bus, the shield must be connected to each device (e.g., by means of clamps).
- Connect the bus shield to a central PE point using short, low-impedance connections with a large surface area (e.g., by means of shield connection clamps).

4.6.2 Terminating the RS-485 bus cable

The RAD-900-IFS wireless module is operated on a 2-wire bus cable. RS-485 bus connections must be terminated at both ends with a 390/150/390 Ω termination network.

Depending on the position of the device on the RS-485 bus cable, the termination network must be activated or deactivated. The DIP switches 1 and 2 are located on the side of the wireless module.

Table 4-1 DIP switches 1 and 2: termination network

		DIP switch	
Device position	**Termination network**	**1**	**2**
RS-485 termination device	ON	ON	ON
RS-485 device	OFF	OFF	OFF

4.6.3 RS-485 pin assignment

In RS-485 mode, you can create a network with several I/O devices. Use a twisted pair bus cable to connect the I/O devices. Fit this bus cable with a termination network at the two furthest points.

- Connect the single wires of the data cable to the COMBICON plug-in screw terminal block (Figure 4-1, item 10).
- Make sure the signal assignment is correct.

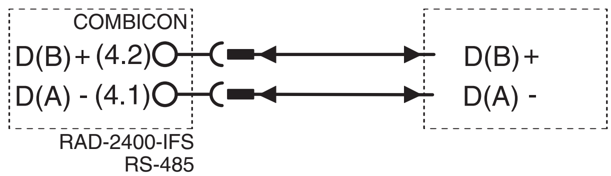


Figure 4-7 RS-485 interface pin assignment

4.6.4 RS-232 pin assignment

In RS-232 mode, point-to-point connections can be established.

> The RS-232 interface of the wireless module is a DTE type (Data Terminal Equipment). This means that terminal point 5.2 (Tx) is always used for transmission and terminal point 5.1 (Rx) is always used for reception.
>
> Only connect the wireless module to devices which meet the requirements of EN 60950.

According to the standard, you can connect a DCE device (Data Communication Equipment) to the RS-232 interface using a 1:1 cable (Figure 4-8). It is also possible to connect a DTE device using a crossed cable (Figure 4-9).

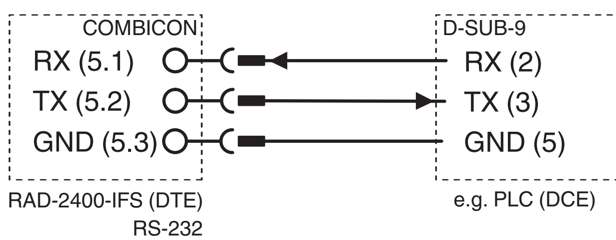


Figure 4-8 RS-232 interface pin assignment (DTE - DCE)

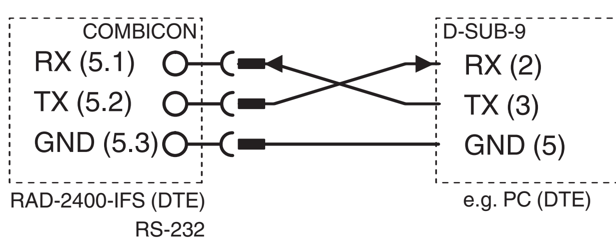


Figure 4-9 RS-232 interface pin assignment (DTE - DTE)

If you are not sure whether the device to be connected is of DTE or DCE type, you can measure the voltage. Measure the voltage between Tx and GND in the idle state.

– If the voltage measures approximately -5 V, it is a DTE device.
– If the voltage measures approximately 0 V, it is a DCE device.

4.6.5 9-pos. D-Sub pin assignment

The RAD-900-IFS provides a 9-pos. D-Sub female connector for attaching RS-232 serial devices.

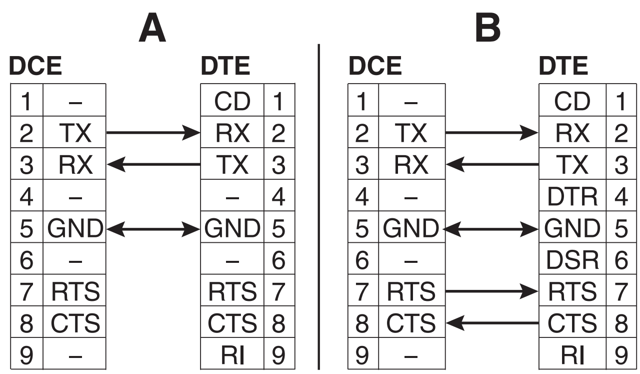


Figure 4-10 9-pos. D-SUB straight-through cable pinouts for 3-wire (A) and 5-wire (B)

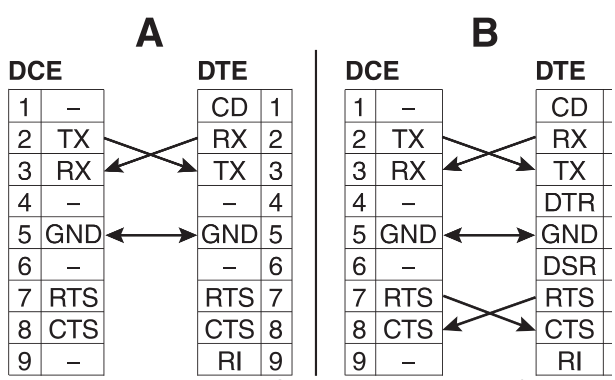


Figure 4-11 9-pos. D-SUB null cable pinouts for 3-wire (A) and 5-wire (B)

4.7 Connecting the antenna

The wireless module is provided with an RSMA antenna socket for an external antenna.

> Install the antenna outside the control cabinet or building.
>
> Observe the installation instructions of the antenna and “Safety regulations and installation notes” on page 13.
>
> Observe the maximum permissible emitted transmission power of 36 dBm. The transmission power can be calculated from:
> device transmission power + antenna gain - cable attenuation
>
> Reduce the device transmission power, if necessary.

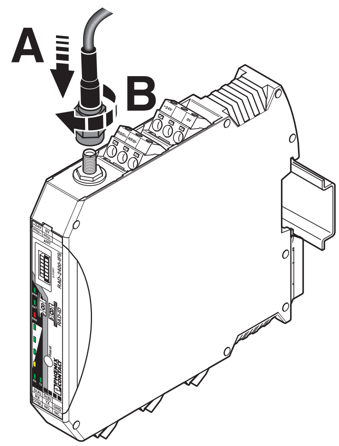


Figure 4-12 Connecting the antenna

5 Configuration and startup

5.1 Default settings of the wireless module

All RAD-900-IFS wireless modules have the same configuration by default upon delivery or by resetting to the default settings at a later stage.

Table 5-1 Default settings of the wireless module

Parameter	Setting
Operating mode	I/O data (wire in/wire out)
Wireless interface	
Net ID	127
RF band	1
Encryption	OFF
Network structure	Star
Device type	Slave
Data rate of the wireless interface	125 kbps
Transmission power	1 W (30 dBm)

In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 30 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software (from page 38 onwards).

5.1.1 Resetting to the default settings

The device can be reset to the default settings either manually or using the PSI-CONF software.

Resetting manually

1. Disconnect the device from the supply voltage.
2. Hold down the SET button located on the front of the device and switch the supply voltage on.
3. Press and hold the SET button until the DAT LED flashes.

Resetting via PSI-CONF software

1. Select “Wireless, RAD-900-IFS” on the “Device Selection” page.
2. Select “Local Device”.
3. Select “Set device to factory default configuration”.

5.1.2 Firmware update

You can download the latest firmware free of charge at phoenixcontact.net/products.

The firmware can be updated using the PSI-CONF software. The device is reset to the default settings after a firmware update.

1. Select “Wireless, RAD-900-IFS” on the “Device Selection” page.
2. Select “Update firmware”.

5.2 Operating mode of the wireless module

The Radioline wireless system offers four different options for signal and data transmission:

Operating mode	Configuration
I/O data mode	Default setting, configuration only possible via thumb-wheel
Serial data mode	Configuration via PSI-CONF software
PLC/Modbus RTU mode	
PLC/Modbus RTU dual mode	

You can select only one operating mode. It is **not** possible to simultaneously transmit I/O signals and serial data.

If the wireless system is operated in an environment where other networks are also present (e.g., additional Radioline networks in the 900 MHz band), then a configuration memory can be used (see “Configuration via CONFSTICK” on page 35). For configuring extended settings of the wireless modules, it is also possible to use the PSI-CONF software (from page 38 onwards).

I/O data mode

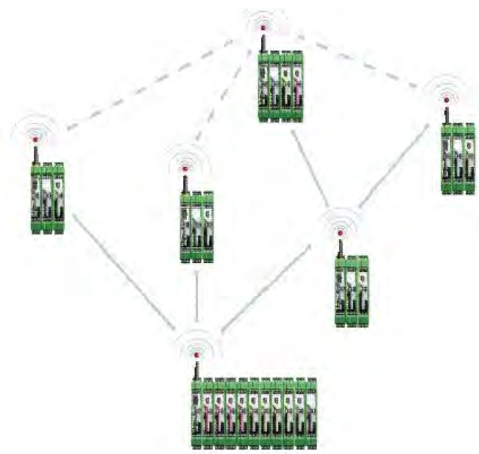


Figure 5-1 I/O data mode

By default, all wireless modules are in the I/O data mode. For simple I/O-to-I/O applications with extension modules, you can easily set the addresses using the thumbwheel. You can therefore establish a wireless connection to other wireless modules without any programming effort (see “Setting the address of the wireless module via the thumbwheel” on page 35 and “Setting the address of the extension modules via the thumbwheel” on page 52).

Serial data mode

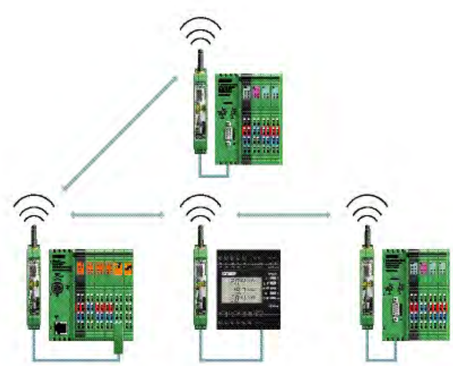


Figure 5-2 Serial data mode

In serial data mode, multiple controllers or serial I/O devices are networked easily and quickly using wireless technology. In this way, serial RS-232 or RS-485 cables can be replaced.

You need to configure each wireless module using the PSI-CONF software (from page 38 onwards).

PLC/Modbus RTU mode

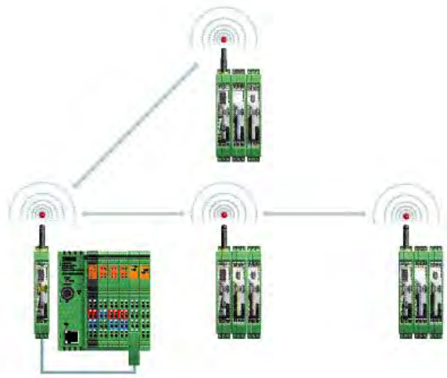


Figure 5-3 PLC/Modbus RTU mode

You can connect the I/O extension modules to the controller directly via the integrated RS-232 and RS-485 interface by means of wireless communication. In PLC/Modbus RTU mode, the master wireless module (RAD ID = 01) operates as a Modbus slave. The master wireless module has its own Modbus address.

You can connect I/O extension modules to each wireless module in the network. The I/O data of the extension module is stored in the internal Modbus memory map of the master wireless module. In addition, the diagnostic data from all wireless devices is stored here.

You need to configure each wireless module using the PSI-CONF software (from page 38 onwards).

PLC/Modbus RTU dual mode

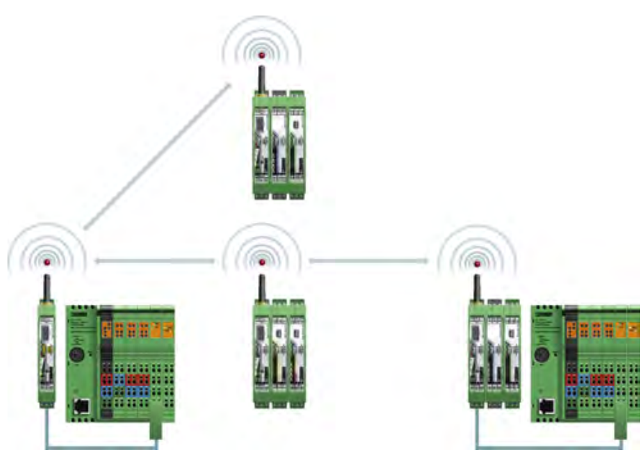


Figure 5-4 PLC/Modbus RTU dual mode

Dual mode combines the PLC/Modbus RTU mode and the serial data mode. Serial Modbus devices can be connected to the RS-232 or RS-485 ports, and you can connect I/O extension modules to each wireless module in the network.

The I/O data of the extension module and the diagnostic data is stored in the internal Modbus memory map of the wireless module. Each wireless module with I/O extension modules has its own Modbus address. In addition, the diagnostic data from all wireless devices can be read from the master wireless module.

You must configure each wireless module using the PSI-CONF software.

5.3 Setting the address of the wireless module via the thumbwheel

Set the desired station address with the yellow thumbwheel on the wireless module. There must be one master (RAD ID = 01) and at least one repeater/slave
(RAD ID = 02 ... 99) in a network.

> Unique addressing is required in a network. If two wireless modules have the same address in a network, the network will not function properly.
>
> Setting the address via the thumbwheel has priority over setting the address via the PSI-CONF software.
>
> After making any change to the module address, press the SET button for one second to apply the setting.

The following settings can be made using the yellow thumbwheel:

Thumbwheel setting	Description	
01	Master address	for networks without repeaters (mesh networks)
02 ... 99	Slave address	
*1	Master address	for networks without repeater (star networks)
*2 ... *9	Slave address	
00	Not permitted	
**	Addressing wireless modules using the PSI-CONF software (address 1 ... 250)	

5.4 Configuration via CONFSTICK

> **WARNING: Explosion hazard when used in potentially explosive areas**
> Do **not** insert or remove the CONFSTICK in a potentially explosive atmosphere.

By default upon delivery, all wireless modules have the same network ID and the same RF band. Using a configuration memory (CONFSTICK), you can configure a unique and secure network without the need for software.

The CONFSTICK is used as a network key. Its network address (network ID) is unique and cannot be assigned via the PSI-CONF software. Only wireless modules with the same network ID are allowed to connect with each other.

You have to configure each individual network device. To this end, you only need one CONFSTICK for all wireless modules in the network. After configuration, you can remove the CONFSTICK from the wireless module.

In addition, the CONFSTICK contains a preset frequency band (RF band). An RF band is a group of frequencies compiled of individual frequencies of the entire 900 MHz band. Different RF bands use different frequencies.

In order to operate several Radioline wireless systems, you should select different RF bands.

> You can set different RF bands between 1 ... 8 and network IDs between 1 ... 127 by using the PSI-CONF software (see page 39).

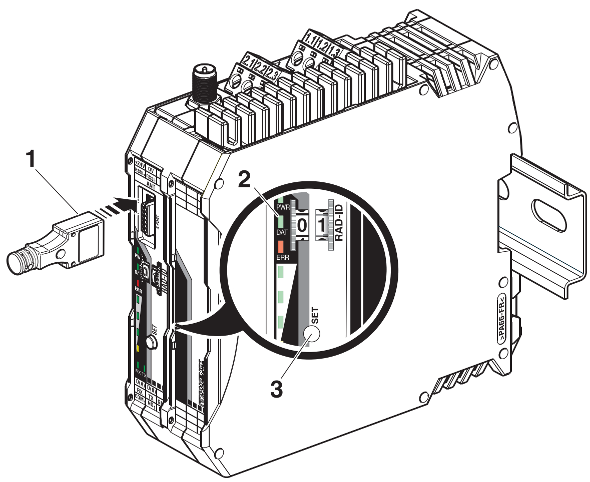


Figure 5-5 Configuration via CONFSTICK

Item	Description
1	RAD-CONF-RF CONFSTICK
2	Status LEDs
3	SET button

1. Carefully insert the CONFSTICK with the 12-pos. IFS connector into the S port of the wireless module.
2. Press the SET button on the wireless module for one second. Parameter read in is started. Read in has been completed when the DAT LED lights up once. The new parameters are activated.
3. Remove the CONFSTICK from the wireless module.
4. Repeat this process for **each** individual wireless module in the network.

5.5 Copying device settings via memory stick

In order to transfer the configuration of a wireless module to another wireless module, you can save the configuration to a memory stick (RAD-MEMORY, Order No. 2902828).

WARNING: Explosion hazard when used in potentially explosive areas
Do **not** insert or remove the memory stick in a potentially explosive atmosphere.

Pay attention to the firmware version of the wireless modules before using the memory stick. In order to ensure that a wireless module is capable of reading the memory stick, it must have the same or later firmware version as the wireless module whose configuration file is to be copied. Wireless modules with a lower firmware version are not able to read the memory stick.

Common network parameters

– Operating mode
– Network ID
– RF band
– Data rate of the wireless interface
– Encryption
– Network type

Individual device parameters

– Station name
– RAD ID
– Transmission power
– List of permitted connections
– Serial interface parameters

5.5.1 Saving parameters from the wireless module to the memory stick

Copying common network parameters and individual device parameters to the memory stick:

1. Press the SET button located on the wireless module and hold down for at least six seconds.
2. The four RSSI bar graph LEDs start a light sequence from bottom to top.
3. Insert the memory stick in the S port of the wireless module. The copying of parameters is started automatically.
4. Wait until the light sequence stops. The write process has been completed.
5. Remove the memory stick from the wireless module.

5.5.2 Reading the memory stick

Reading in common network parameters via the memory stick

1. Insert the memory stick in the S port of the wireless module.
2. Press the SET button located on the wireless module and hold down for at least one second. Parameter read in is started. Read in has been completed when the DAT LED lights up once. The new parameters are activated.
3. Remove the memory stick from the wireless module.

Reading in common network parameters and individual device parameters via the memory stick

This function enables all common network parameters and individual device parameters to be read into the wireless module. A full copy of devices can be created, e.g., as a backup copy.

1. Insert the memory stick in the S port of the wireless module.
2. Press the SET button located on the wireless module and hold down for at least six seconds. Parameter read in is started, the DAT LED flashes.
3. The read in process has been completed once the DAT LED stops flashing. The new parameters are activated.
4. Remove the memory stick from the wireless module.

If an error is detected while saving or checking the data, the DAT and ERR LEDs flash simultaneously.

5.6 Configuration via PSI-CONF software

You can make special settings using the PSI-CONF configuration and diagnostics software. The software is available to download at phoenixcontact.net/products. A PC with a Windows operating system is required to use the software. Use the RAD-CABLE-USB (Order No. 2903447) USB cable for configuration and diagnostics.

WARNING: Explosion hazard when used in potentially explosive areas
The USB cable must **not** be used in potentially explosive areas.

For additional information on the USB cable, please refer to the RAD-CABLE-USB package slip. The latest documentation can be downloaded at phoenixcontact.net/products.

Install the software and the USB driver for the RAD-CABLE-USB cable. Follow the software wizard.

5.6.1 Extended configuration, individual settings

After reading an existing network project or creating a new project, the network settings can be modified under “Individual Settings”. The wireless network can be optimized and adapted to your special requirements. When moving the mouse over the individual network parameters, you obtain a short description under “Help”.

> If several wireless systems are operated parallel and in close proximity, you are required to set the RF band and the network ID. These parameters can be set via the PSI-CONF software or by using a CONFSTICK (see “Configuration via CONFSTICK” on page 35).

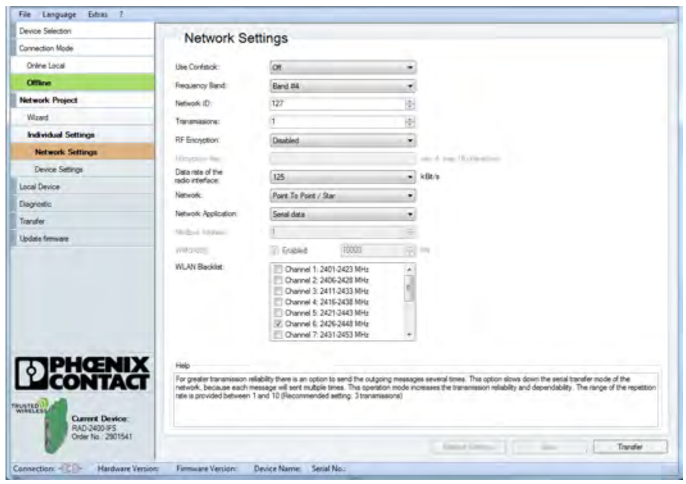


Figure 5-6 PSI-CONF software: Network Settings

5.6.2 Data transmission speed of the wireless interface

The range is an important parameter in industrial wireless applications, especially in outdoor applications. Even in cases where long ranges do not have to be covered, good receiver sensitivity enables transmission in harsh outdoor conditions, e.g., when there is no direct line of sight.

The receiver sensitivity determines the signal amplitude which can just about be received by the wireless module. The lower the data transmission speed of the wireless interface, the higher the receiver sensitivity and thereby the range.

> Adjust the data transmission speed of the wireless interface to the respective application using the PSI-CONF software (default setting = 125 kbps).

Table 5-2 Data transmission speed of the wireless interface

Data transmission speed	Typical receiver sensitivity	Typical link budget	Potential distance with line of sight and a system reserve of 12 dB
500 kbps	-95 dBm	-125 dBm	12 km
250 kbps	-102 dBm	-132 dBm	25 km
125 kbps	-105 dBm	-135 dBm	35 km (default setting)
16 kbps	-112 dBm	-142 dBm	80 km

You can achieve transmission within the kilometer range using the wireless module if the following conditions are fulfilled:

– Suitable gain antennas are used
– Line of sight
– Adherence to the Fresnel zone

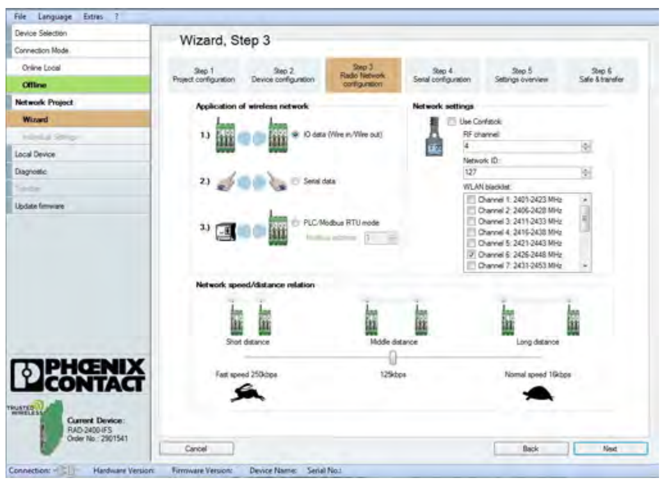


Figure 5-7 PSI-CONF software: Wizard, Step 3

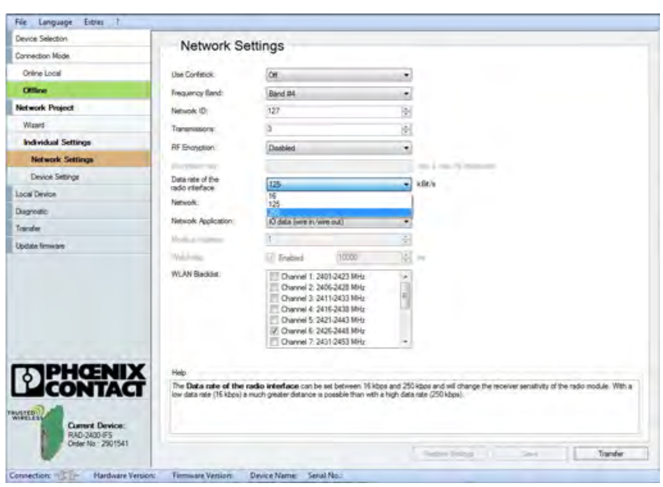


Figure 5-8 PSI-CONF software: Setting the data transmission speed

5.6.3 Device settings

In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 30 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software.

You can assign a device name or set the transmission power under “Device Settings”. All device parameters are listed on the “Overview” tab.

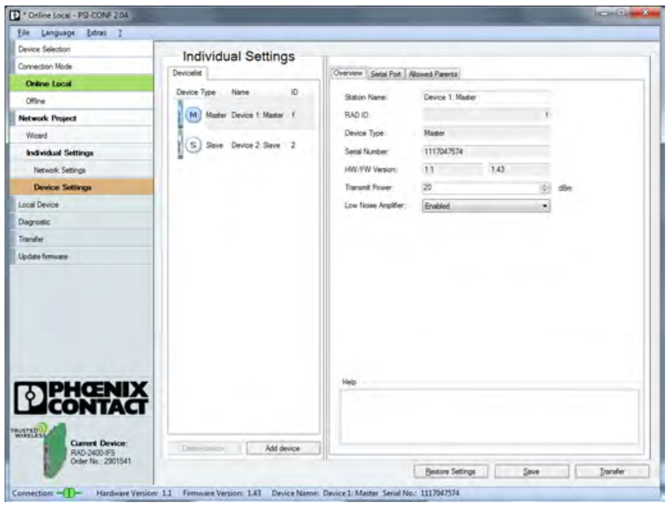


Figure 5-9 PSI-CONF software: Individual Settings, Overview

Depending on the operating mode, you can configure the serial interface under “Individual Settings” on the “Serial Port” tab.

In I/O data mode (default upon delivery), both interfaces are deactivated. To activate the serial interface, select the “Serial data,” “PLC/Modbus RTU mode,” or “PLC/Modbus RTU dual mode” network application under “Network Settings”.

> You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.

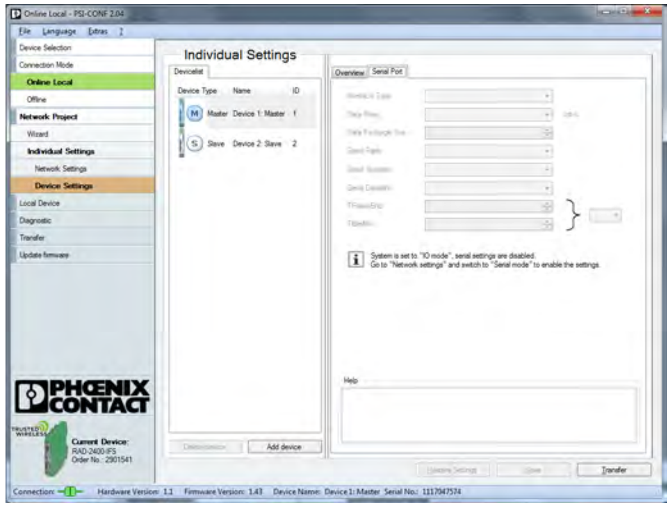


Figure 5-10 PSI-CONF software: Individual Settings, Serial Port

You can define the wireless modules to which a connection may be established on the “Allowed Parents” tab under “Individual Settings”. This setting is required, for example, when creating repeater chains. Repeater chains are used to circumvent obstacles or to set up redundant wireless paths by means of several repeaters.

> The “Allowed Parents” tab is only available if the “Line/Mesh” network type has been selected.

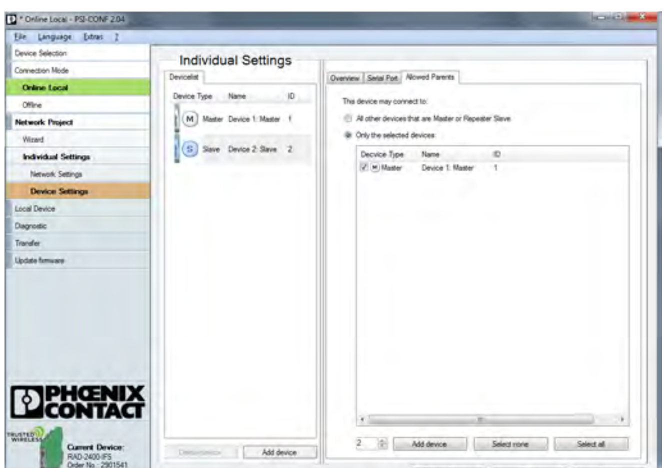


Figure 5-11 PSI-CONF software: Individual Settings, Allowed Parents

5.7 Diagnostics on the wireless module

5.7.1 Diagnostic LEDs

A total of nine LEDs on the wireless module indicate the operating states.

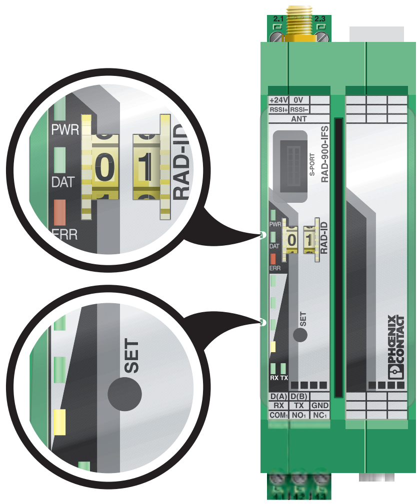


Figure 5-12 Diagnostic LEDs of the RAD-900-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration mode
ON	Cyclic data communication

ERR LED

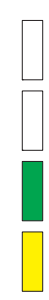
The red ERR LED indicates the error status.

OFF	No error	
Flashing	Slow (1.4 Hz)	**Wireless module in I/O data mode** – Double assignment of I/O-MAP address (e.g., two input modules with the same I/O-MAP address) – Missing input module – Missing output module – RAD ID changed **Wireless module in PLC/Modbus RTU mode** – Double assignment of I/O-MAP address (e.g., two input modules with the same I/O-MAP address) – RAD ID changed – No Modbus communication
	Fast (2.8 Hz)	Wireless connection interrupted
ON	Local bus error (e.g., input or output module not read)	

5.7.2 LED bar graph

The LED bar graph indicates the receive signal strength.

Table 5-3 LED bar graph

Bar graph	LEDs	Receive signal		RSSI voltage
	All 4 LEDs light up	Maximum signal strength		2.5 … 3 V
		16k	-75 dBm	
		125k	-70 dBm	
		250k	-65 dBm	
		500k	-60 dBm	
	Yellow and 2 green LEDs light up	Very good signal		2 … 2.5 V
		16k	-85 dBm	
		125k	-80 dBm	
		250k	-75 dBm	
		500k	-70 dBm	
	Yellow and 1 green LEDs light up	Good signal		1.5 … 2 V
		16k	-95 dBm	
		125k	-90 dBm	
		250k	-85 dBm	
		500k	-80 dBm	
	Yellow LED lights up	Low signal		1 … 1.5 V
		16k	LINK	
		125k	LINK	
		250k	LINK	
		500k	LINK	
	OFF	Not connected, configuration mode or overload[1]		0 V

[1] In order to be able to cover the greatest possible distances, the preamplifier has been activated and transmission power set to 30 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software.

LED bar graph - light sequence

The light sequence from bottom to top signalizes:

- Firmware update or
- Wireless module is in write mode for the memory stick

TX LED, transmit data

The green TX LED indicates communication with the RS-232/RS-485 interface. The wireless module is transmitting data.

> When using “Wire in/Wire out” mode, the TX LED of the master wireless module always flashes to scan for RAD-RS485-IFS modules.

RX LED, receive data

The green RX LED indicates communication with the RS-232/RS-485 interface. The wireless module is receiving data.

SET button

You can confirm a station change with the SET button, without performing a power up. Station changes include:

– Changing the RAD ID address of the wireless module
– Changing the I/O-MAP address of the extension module
– Adding or remove an I/O extension module
– Using a CONFSTICK or memory stick

After making any change, press the SET button for at least one second to apply the settings. The DAT LED starts flashing. Read in has been completed when the DAT LED stops flashing.

RF link relay

The RF link relay in the wireless module diagnoses the state of the wireless connection. The relay picks up when the wireless connection is established. If the wireless module does not receive a data packet correctly over a period of 10 seconds, the relay drops out. The relay picks up again automatically when the wireless connection is re-established.

The RF link relay has been designed as a PDT contact.

> The RF link relay can be used as a fault message contact to indicate the failure of the wireless connection to the controller.

RSSI test socket

A voltage measuring device can be connected to the RSSI test socket to measure the RSSI voltage between 0 V ... 3 V. The RSSI voltage depends on the data rate set for the wireless interface. The higher the RSSI voltage, the better the wireless connection.

For example, the RSSI voltage may be helpful when positioning and aligning the antenna. The recommended minimum signal strength is 2.0 V DC. This results in a power reserve of approximately 10 dB which ensures communication even in the event of unfavorable transmission conditions.

RSSI LED bar graph

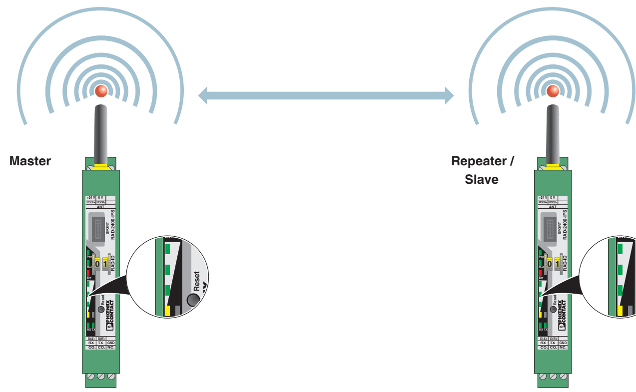


Figure 5-13 Bar graph for point-to-point connection

In a point-to-point connection with only two wireless modules, the LED bar graph is active on both the master and repeater/slave.

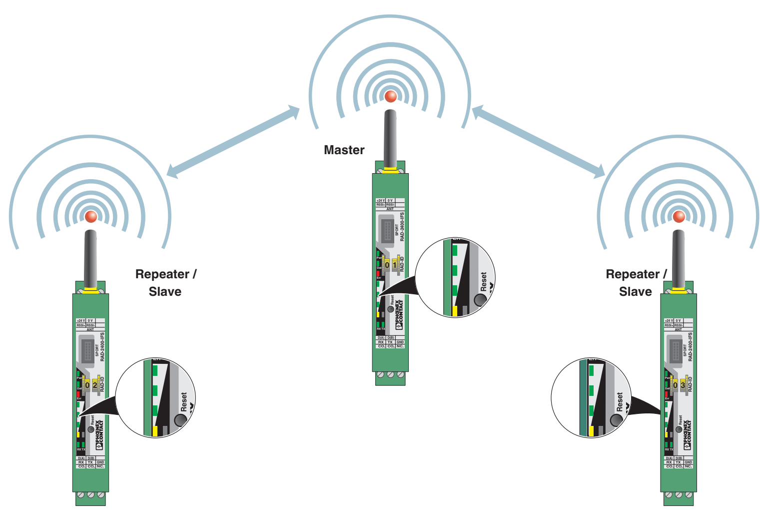


Figure 5-14 Bar graph for point-to-multipoint connection

In a wireless network with more than one repeater/slave, only the yellow LED on the master is permanently on. The signal strength is displayed on the repeaters/slaves. The signal strength indicated is always that of the next wireless module in the direction of the master (parents).

You can read the RSSI values via the serial interface of the master wireless module using Modbus RTU commands (see Section “Modbus memory map” on page 70).

5.8 Diagnostics via PSI-CONF software

You can display all current device settings for the station under “Diagnostic” on the “Overview” tab.

Select the desired station from the device list.

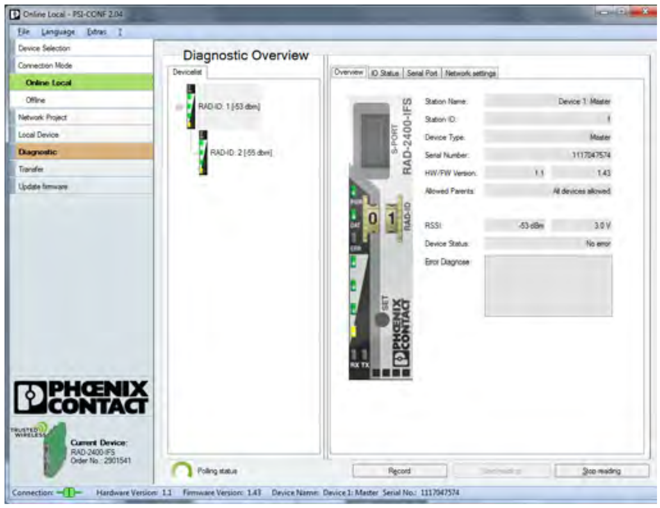


Figure 5-15 PSI-CONF software: Diagnostic, Overview

The entire wireless network can be diagnosed using the master wireless module (RAD ID = 01).

When operating the network in serial data mode, it may not be possible to diagnose all devices. In this case, stop the serial application in order to allow for complete diagnostics.

For information on troubleshooting, please refer to Section “Detecting and removing errors” on page 139.

If an error occurs in the network, an error message is displayed under “Device Status”. If the error is no longer present, the error message is reset.

Possible error message:

- Missing input module
- Missing output module
- Double assignment of I/O-MAP address
- Error on IFS bus
- Wireless connection interrupted
- RAD ID changed
- CONFSTICK has not yet been inserted

The “I/O Status” tab displays the status and the current values of the connected I/O extension modules.

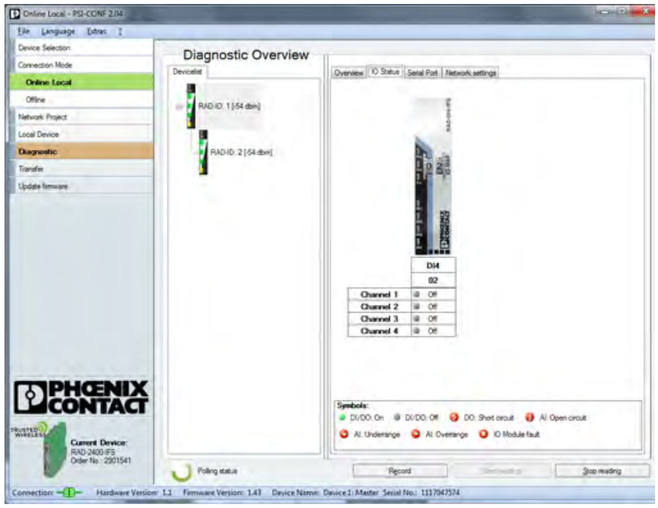


Figure 5-16 PSI-CONF software: Diagnostic, I/O Status

The “Serial Port” tab indicates the currently set parameters of the RS-232/RS-485 interface.

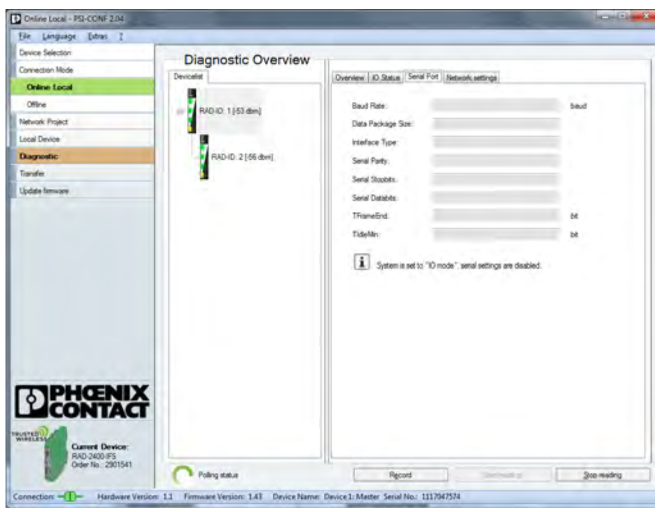


Figure 5-17 PSI-CONF software: Diagnostic, Serial Port

The “Network Settings” tab shows the currently set network parameters as well as the settings of the CONFSTICK, if used.

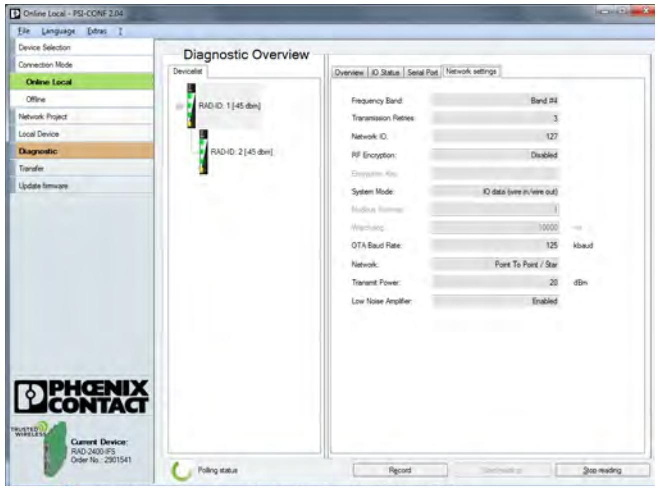


Figure 5-18 PSI-CONF software: Diagnostic, Network Settings

5.8.1 Recording parameters

The following parameters can be recorded using the PSI-CONF software:

– Signal strength
– Network structure
– Status and current values of the connected extension modules

1. Click “Record” under “Diagnostic”.
2. Select “Network diagnostics” or “I/O diagnostics” under “Select the type of data to record”.
3. Under “Recording interval”, you can specify how often the values should be recorded.
   For network diagnostics: Activate “Record signal strength” or “Record network structures”.
   For I/O diagnostics: Select the desired stations.
4. Select a storage location and click on “Start Recording”.

Diagnostic data is now written to a CSV file which can be opened, for example, with Excel.

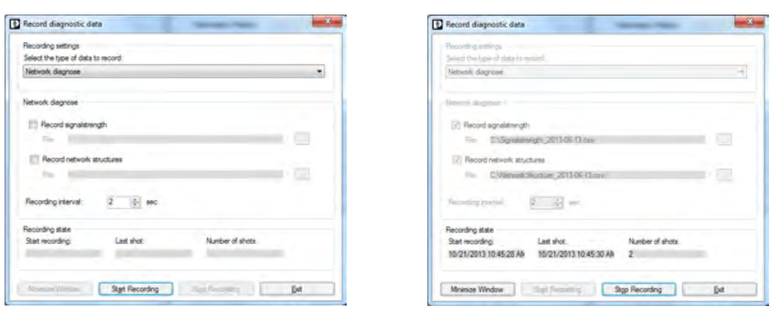


Figure 5-19 PSI-CONF software: Record diagnostic data, Network diagnostics

5.9 Starting up I/O extension modules

5.9.1 Combinations of extension modules

Several appropriate output modules at different stations can be assigned to one digital or analog input module. The inputs are transmitted in parallel to the outputs. The channels of the input module are mirrored to the channels of the output module.

It is **not** possible to separately assign the individual input channels of an extension module to different output modules.

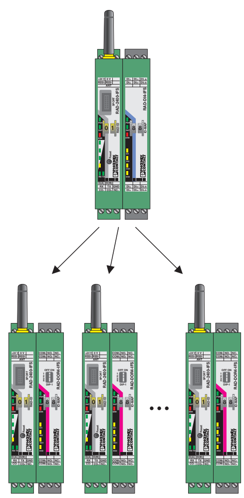


Figure 5-20 Assignment of digital inputs and digital outputs

The combined RAD-DAIO6-IFS extension modules can only be assigned in pairs, because each module is provided with inputs and outputs. That is why only two modules in the network may have the same I/O MAP address.

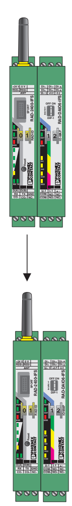


Figure 5-21 RAD-DAIO6-IFS assignment: analog/digital inputs and outputs

Table 5-4 Assignment of input and output modules

Input module		Output module	
2901537	RAD-AI4-IFS	2901538	RAD-AO4-IFS
2904035	RAD-PT100-4-IFS	2901538	RAD-AO4-IFS
2901535	RAD-DI4-IFS	2901536	RAD-DOR4-IFS
2901539	RAD-DI8-IFS	2902811	RAD-DO8-IFS
2901533	RAD-DAIO6-IFS	2901533	RAD-DAIO6-IFS

5.9.2 Setting the address of the extension modules via the thumbwheel

For an I/O-to-I/O transmission of signals, you must assign a corresponding output module to the input module. Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the I/O extension module.

Addressing extension modules

- Use the thumbwheel to set the address.
- Press the SET button on the front of the wireless module to read the current configuration.

The following settings can be made using the white thumbwheel:

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

The following conditions must be met:

– You can assign a maximum of 1 ... 99 addresses to the extension modules in the entire wireless network.

Wireless module in I/O data mode

– The input module **must** be provided with the same I/O-MAP address as the assigned output module at the other wireless station (I/O mapping). Output modules with the same I/O-MAP address may appear several times in the network at different stations.
– The I/O-MAP address of an input module may only appear once in the network.
– The channels of the input module are directly assigned to the channels of the output module:

Input module		Output module
Channel 1	→	Channel 1
Channel 2	→	Channel 2
...	→	...

It is **not** possible to individually assign the channels of the input and output modules.

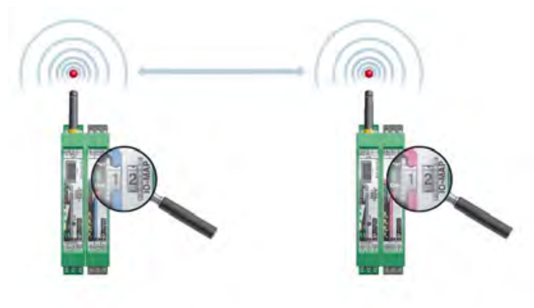


Figure 5-22 Input module and output module with the same address

Wireless module in PLC/Modbus RTU mode

– Output modules **may not have** the same I/O-MAP address as input modules. Exception: Output modules with the same I/O-MAP address may appear several times in the network at different stations.
– The I/O-MAP address of an input module may only appear once in the network.
– The input and output data is saved in a Modbus memory map in the master wireless module. You can read or write the process data via the serial interface of the master wireless module (RAD ID = 01) using the Modbus RTU command. The process data tables can be found starting at “Modbus memory map” on page 70.

5.9.3 Wireless module in PLC/Modbus RTU dual mode

– Each wireless module may be assigned a Modbus address. The master wireless module Modbus address may be changed from 01 if an existing Modbus device is already assigned this address. A Modbus address may only appear once in the network.
– Output modules may not have the same I/O-MAP address as input modules on a single wireless device (station). Exception: Output modules with the same I/O-MAP address may appear several times at the same station.

– The input and output data is saved in a Modbus memory map in the wireless module. You can read or write the process data via the serial interface of the master wireless module (RAD ID = 01) using the Modbus RTU command. The process data tables can be found starting at “Modbus memory map” on page 70.

5.10 Startup time of the wireless station

Once a wireless station has been started up (power “ON”), the wireless module will take 15 seconds to be ready for operation. Each linked I/O extension module increases the startup time by 3 seconds.

Startup time of a wireless station =
15 seconds + (number of I/O modules x 3 seconds)

Accordingly, a complete wireless station with 32 I/O extension modules requires a startup time of 111 seconds. Only after this period of time has elapsed is the wireless station ready for operation.

6 Serial data mode

In serial data mode, multiple controllers or serial I/O devices are networked quickly and easily using wireless technology. In this way, serial RS-232 or RS-485 cables can be replaced.

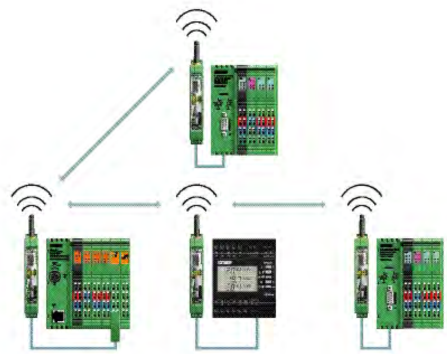


Figure 6-1 Serial data mode

You can configure the serial interface of the RAD-900-IFS wireless module using the PSI-CONF software. In order to connect the wireless module to the PC, you need the RAD-CABLE-USB cable (Order No. 2903447).

WARNING: Explosion hazard when used in potentially explosive areas

The USB cable must **not** be used in potentially explosive areas.

When operating the network in serial data mode, it may not be possible to diagnose all devices. In this case, stop the serial application in order to allow for complete diagnostics.

Using the PSI-CONF software, you can assign different serial settings to the devices under "Individual Settings".

- Start the PSI-CONF software.
- Follow the software wizard.
- Once you have run through all steps of the wizard, you can save the project and transmit it to the wireless modules.

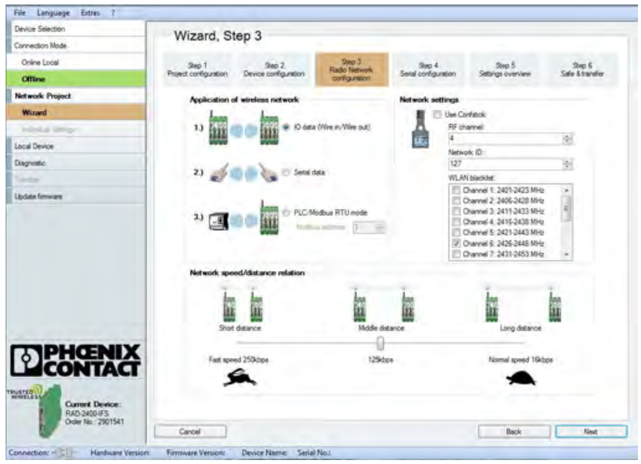


Figure 6-2 PSI-CONF software: Wizard, Step 3

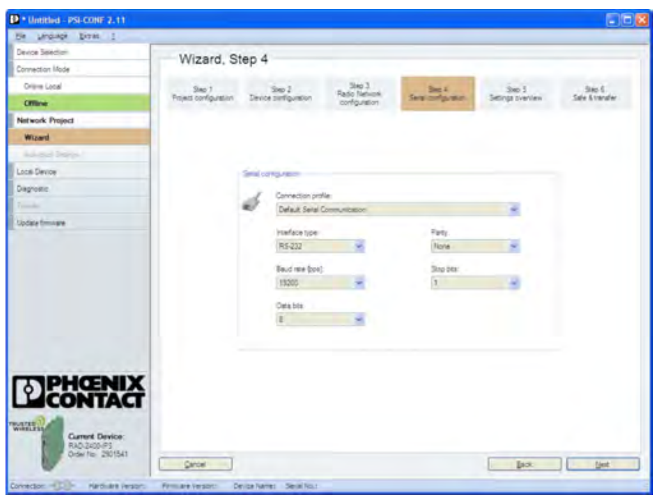


Figure 6-3 PSI-CONF software: Wizard, Step 4

6.1 Frame-based data transmission

$T_{IdleMin}$ parameter (minimum pause between two frames)

The $T_{IdleMin}$ parameter refers to the minimum pause that must elapse between two frames on the output side (wireless module is transmitting data via serial interface).

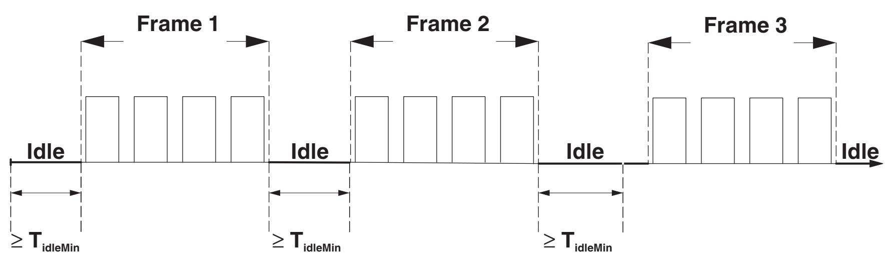


Figure 6-4 Frame-based data transmission: $T_{IdleMin}$ parameter

$T_{FrameEnd}$ parameter

$T_{FrameEnd}$ is the time which is kept by the transmitting wireless module between two frames.

If the data received by the wireless module is followed by a certain period of time where no further data is received, the wireless module assumes that the frame has arrived in its entirety. The frame is then transmitted. This period of time is referred to as $T_{FrameEnd}$.

$T_{FrameEnd}$ must be shorter than the minimum interval between two frames ($T_{FrameEnd} < T_{IdleMin}$). $T_{FrameEnd}$ must, however, also be greater than the maximum interval that is permitted between two characters in a frame. Otherwise the frame might be fragmented.

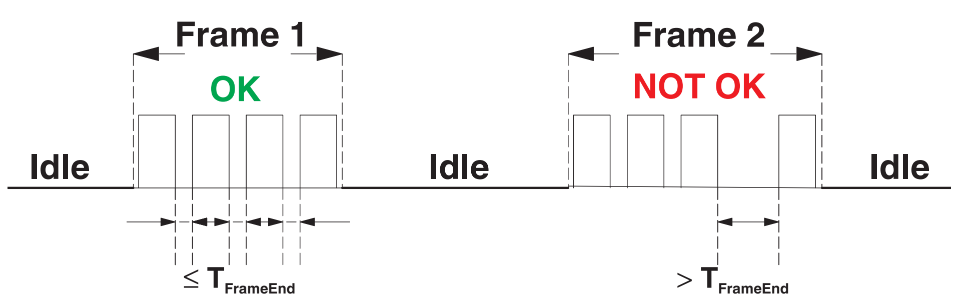


Figure 6-5 Frame-based data transmission: $T_{FrameEnd}$ parameter

Setting telegram pauses, based on the example of Modbus/RTU

A frame is also referred to as a telegram. The length of the transmission pause between the telegrams depends on the set data rate. The beginning and end of a telegram is recognized by means of a time condition. A pause of 3.5 characters means that the telegram is complete and the next character is to be interpreted as the slave address. A telegram must therefore be sent as a continuous data flow. If there is an interruption of more than 1.5 characters within a telegram, the data will be discarded by the receiver.

If the master is not able to transmit the successive characters quickly enough and the communication is aborted, you must increase the minimum pause time ($T_{FrameEnd}$) between the individual characters of a telegram. Frames with a length of 1480 characters can be transmitted by the Radioline wireless system.

- In order to adapt data transmission to other protocols, it is possible to adapt the $T_{FrameEnd}$ and $T_{IdleMin}$ parameters. Set the interface parameters under “Individual Settings”.

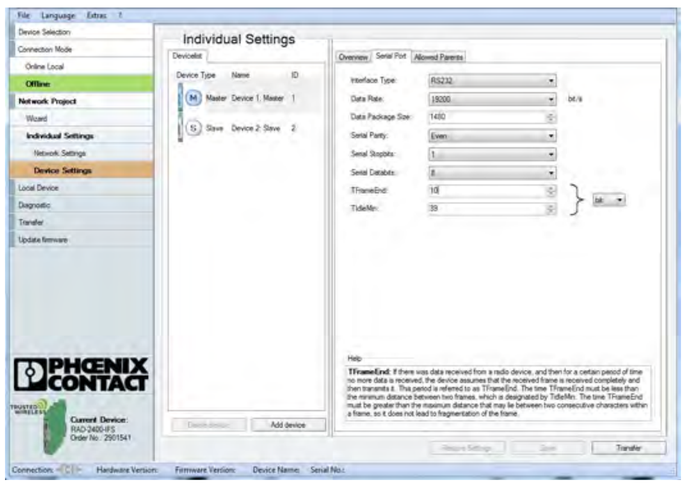


Figure 6-6 PSI-CONF software: Individual Settings

7 PLC/Modbus RTU mode

> The PLC/Modbus RTU mode is available for firmware version 1.30 or later. If necessary, start an update using the PSI-CONF software (version 2.03 or later).

Activate the PLC/Modbus RTU mode using the PSI-CONF software (from page 38 onwards).

In PLC/Modbus RTU mode, you can read the I/O values of the extension modules connected to the wireless slave modules via the Modbus RTU protocol (I/O to serial). The wireless module provides an RS-232 or RS-485 interface for this purpose. In PLC/Modbus RTU mode, the master wireless module works as a Modbus slave and has its own Modbus slave address.

You can connect I/O extension modules to each wireless device in the network. A wireless network can have a maximum of 99 extension modules. Use the white thumbwheel to set the I/O-MAP addresses.

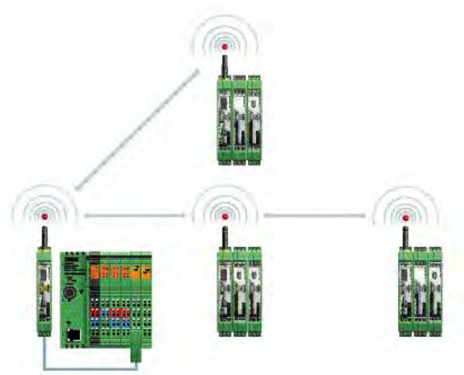


Figure 7-1 PLC/Modbus RTU mode

7.1 Configuration via PSI-CONF software

1. Start the PSI-CONF software (see page 38).
2. Create a new network project.
3. Follow the software wizard.

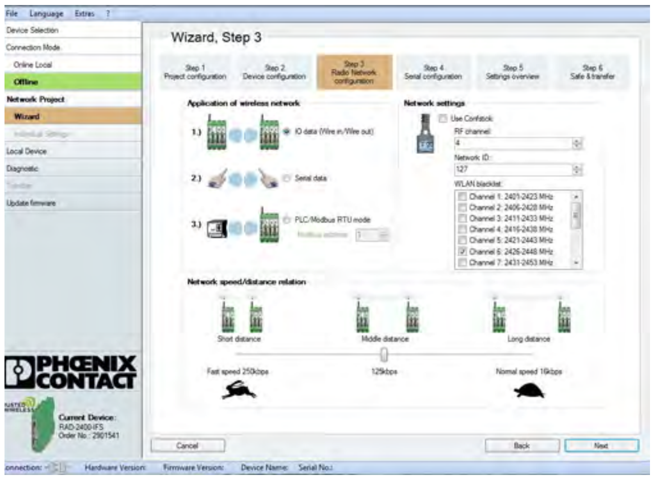


Figure 7-2 PSI-CONF software: Wizard, Step 3

4. Select “PLC/Modbus RTU mode” and assign a Modbus address.
5. Follow the software wizard.

The Modbus address is a unique address in the Modbus network. It is only assigned to the master wireless module (RAD ID = 01). You can assign an address between 1 ... 247.

In order to enable the master wireless module to communicate with a controller via the RS-232 or RS-485 interface, you are required to set the interface parameters. Please note that the controller settings must match the settings of the wireless module.

Table 7-1 Configuration via PSI-CONF software

Parameter	Possible values	Default setting
Interface type	RS-232, RS-485	RS-232
Data rate	300 ... 115,200 bps	19,200 bps
Parity	None, even, odd	None
Number of stop bits	1; 2	1
Number of data bits	8	8
Modbus address	1 ... 247	1

The Modbus connection between the controller and the wireless module can be monitored via a watchdog. For additional information on the watchdog, refer to page 61.

7.2 Addressing I/O extension modules

In PLC/Modbus RTU mode, a wireless network can have a maximum of 99 I/O extension modules.

Use the white thumbwheel on the I/O extension module to set the I/O-MAP address. You can find information on addressing extension modules from page 52 onwards.

7.3 Watchdog

The Modbus telegram watchdog monitors the connection between the master wireless module and the controller. It is triggered each time a Modbus telegram is received correctly. You can activate the watchdog using the PSI-CONF software.

- Select the “Network Settings” item under “Individual Settings”. You can set a watchdog time between 200 ms ... 65,000 ms.

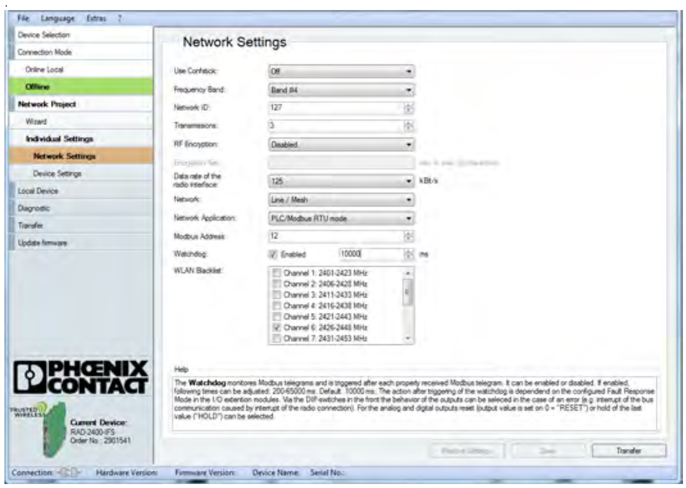


Figure 7-3 PSI-CONF software: Individual Settings, Network Settings

If the watchdog is triggered, an action will be performed on the I/O output modules. You can set this behavior in the event of an error using the DIP switches on the front.

– OFF = RESET: Output value is set to 0
– ON = HOLD: Hold last output value

For more detailed information regarding switch setting for the different extension modules, please refer to Section “Description of I/O extension modules” on page 85.

If the watchdog is activated and Modbus communication interrupted, the red ERR LED will flash on all wireless modules in the network. Depending on the DIP switch settings, the output modules issue the corresponding hold or reset value.

8 PLC/Modbus RTU dual mode

PLC/Modbus RTU dual mode is available for firmware version 1.80 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.33 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

Activate the PLC/Modbus RTU dual mode using the PSI-CONF software (from page 38 onwards).

In PLC/Modbus RTU dual mode, you can read the I/O values of the extension modules connected to the wireless slave modules via the Modbus RTU protocol (I/O to serial). In addition, serial Modbus devices can be connected over the wireless network. The master wireless module provides an RS-232 or RS-485 interface to a Modbus RTU master.

In PLC/Modbus RTU dual mode, all the wireless modules work as Modbus slaves and have unique Modbus slave addresses. The Modbus ID of each wireless module is set using the yellow thumbwheel.

You can connect I/O extension modules to each wireless device in the network. A wireless station can have a maximum of 32 extension modules. Use the white thumbwheel to set the I/O-MAP addresses.

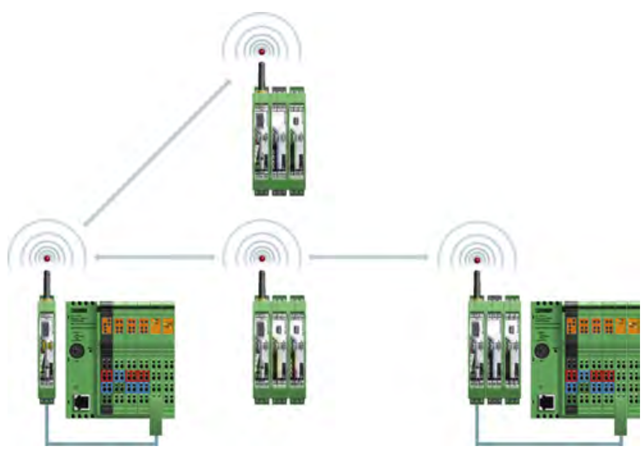


Figure 8-1 PLC/Modbus RTU dual mode

8.1 Configuration via PSI-CONF software

1. Start the PSI-CONF software (see page 38).
2. Create a new network project.
3. Follow the software wizard.

Figure 8-2 PSI-CONF software: Wizard, Step 3

4. Select “PLC/Modbus RTU dual mode” and assign a Modbus address.
5. Follow the software wizard.

> The Modbus address is a unique address in the Modbus network. You can assign an address between 1 ... 247.

In order to enable the master wireless module to communicate with a controller via the RS-232 or RS-485 interface, you are required to set the interface parameters. Please note that the controller settings must match the settings of the wireless module.

Table 8-1 Configuration via PSI-CONF software

Parameter	Possible values	Default setting
Interface type	RS-232, RS-485	RS-232
Data rate	300 ... 115,200 bps	19,200 bps
Parity	None, even, odd	None
Number of stop bits	1; 2	1
Number of data bits	8	8
Modbus address	1 ... 247	1

The Modbus connection between the controller and the wireless module can be monitored via a watchdog. For additional information on the watchdog, refer to page 65.

8.2 Addressing I/O extension modules

In PLC/Modbus RTU dual mode, a wireless station can have a maximum of 32I/O extension modules.

Use the white thumbwheel on the I/O extension module to set the I/O-MAP address. You can find information on addressing extension modules from page 52 onwards.

8.3 Watchdog

The Modbus telegram watchdog monitors the connection between the master wireless module and the controller. It is triggered each time a Modbus telegram is received correctly. You can activate the watchdog using the PSI-CONF software.

- Select the “Network Settings” item under “Individual Settings”. You can set a watchdog time between 200 ms ... 65,000 ms.

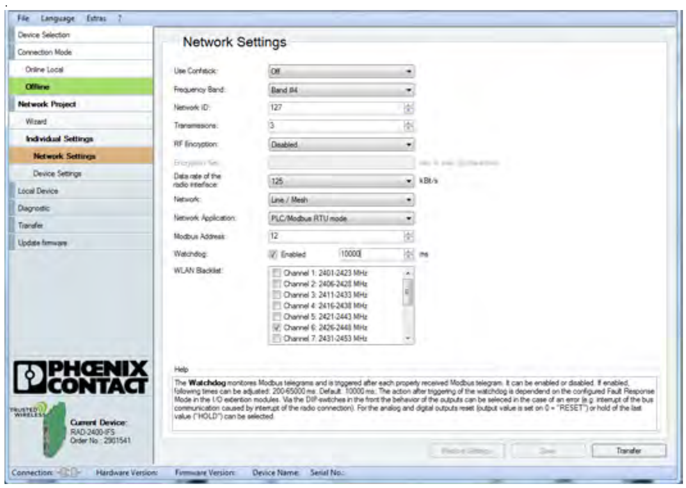


Figure 8-3 PSI-CONF software: Individual Settings, Network Settings

If the watchdog is triggered, an action will be performed on the I/O output modules. You can set this behavior in the event of an error using the DIP switches on the front.

– OFF = RESET: Output value is set to 0
– ON = HOLD: Hold last output value

For more detailed information regarding switch setting for the different extension modules, please refer to Section “Description of I/O extension modules” on page 85.

If the watchdog is activated and Modbus communication interrupted, the red ERR LED will flash on all wireless modules in the network. Depending on the DIP switch settings, the output modules issue the corresponding hold or reset value.

9 Addressing I/O extension modules with Modbus RTU

9.1 Modbus function codes

In the Modbus protocol, the function codes define which data is to be read or written. With a single request, the registers 1 ... 123 can be read or written.

Table 9-1 Supported Modbus function codes

Code number	Function code	Description
fc 03	Read Holding Register	Read process output data (address area 40010 ... 40999)
fc 04	Read Input Register	Read process input data (address area 30010 ... 30999)
fc 16	Write Multiple Registers	Write multiple output registers word by word

Other function codes exist in the Modbus protocol, but they are not supported.

9.2 Modbus protocol

The data is transmitted using the Modbus/RTU (Remote Terminal Unit) protocol. Communication takes place according to the master/slave method. The Modbus master initiates communication with a request to the slave. If the slave detects that its address has been accessed by the master, the slave always sends a response.

Only the master is able to initiate communication. The slaves are not able to initiate communication and do not communicate with each other.

The connected extension modules write the analog or digital input and output values to an internal register. The Modbus master (e.g., a PLC) can read the individual registers using the Modbus address of the slaves. The data to be transmitted is always included in a defined frame. The frame is referred to as telegram.

The Modbus protocol defines the format of the telegrams. If an error occurs when the telegram is received on the slave side, or if the slave is unable to carry out the master request, an error telegram is sent back to the master.

Request from master

The function code in the request informs the addressed slave which action is to be carried out. The address and data bytes contain all additional information that the slave requires in order to carry out the action.

Example: The master uses function code 03 to request the slave to read the process output data and send its content to the master. The data and address bytes need to include the following information: from which register reading should start and how many registers should be read. Using the CRC check value, the slave is able to detect whether the complete telegram has been received.

Response from slave

If the response from a slave is valid, the function code will match the request from the master. The address and data field contains the data recorded by the slave (e.g., register values).

The function code is modified in the event of an error. The address and data field then contains a code that describes the error. By using the CRC check value, the master is able to determine whether the telegram content is valid or not.

The Modbus/RTU telegrams are separated by telegram pauses known as end-of-frame times. The end-of-frame time must be at least 3.5 x as long as the time required for one transmitted character. The end-of-frame time cannot be changed.

Table 9-2 Modbus protocol: structure of telegrams (frames)

Frame	Description	Size
Slave address	Slave address, valid area 1 ... 247	8 bits
Function code	Definition whether the parameter is to be read or written	8 bits
Address	Register address	16 bits
Data	– E.g., from the master: Which parameters are requested? – E.g., from the slave: Content of the requested parameters	N x 16 bits
CRC (Cyclic Redundancy Check)	Test value for the cyclic redundancy check in order to detect errors in data transmission	16 bits

9.3 Addressing registers

Function code 04

You must enter 0000 (hex0000) as the start address in order to read register 30001. The address area 3xxxx is already defined by the function code field.

Function codes 03 and 16

In order to read/write registers 40032 ... 40039, you must enter 0031 (hex001F) as the start address. The address area 4xxxx is already defined by the function code field.

9.4 Module type and error code register

You can read the module type and data currentness of the I/O extension modules from the registers 30xx0 and 40xx0.

Table 9-3 Module type and currentness of data

30xx0, 40xx0[1]				**Module type and currentness of data**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							X[2]	Module type							

[1] xx = I/O-MAP address set using the thumbwheel

[2] X = Currentness of data, bit 8

The individual I/O extension modules can be clearly distinguished by the module type. The module type ID of the extension module can be read in the Modbus register.

Table 9-4 Module type IDs

Module type	**Order No.**	**Module type ID**
Analog inputs		
RAD-AI4-IFS	2901537	20_{hex}
RAD-PT100-4-IFS	2904035	21_{hex}
Analog outputs		
RAD-AO4-IFS	2901538	30_{hex}
Digital inputs		
RAD-DI4-IFS	2901535	01_{hex}
RAD-DI8-IFS	2901539	02_{hex} (static mode)
		40_{hex} (pulse counter mode)
Digital outputs		
RAD-DOR4-IFS	2901536	10_{hex}
RAD-DO8-IFS	2902811	11_{hex}
Analog/digital inputs and outputs		
RAD-DAIO6-IFS	2901533	60_{hex}

“Module type” register value

If the module type in the register is invalid or unavailable, then the register value is 0.

“Currentness of data” register value

If the data in the register is not up-to-date, the register value is 1. This is, for example, the case if the wireless connection to an input module fails. The input process data is then retained in the Modbus table, but is no longer updated. In the case of an output module, the “Currentness of data” register value is set to 1 until the output process data has been written to the Modbus registers.

The read I/O data is only valid and current if a valid module type value is returned by the slave and the “Currentness of data” register value equals 0.

9.4.1 Assigning I/O extension modules to the register

Use the white thumbwheel on the I/O extension module to assign an I/O-MAP address in the Modbus memory map. Example: If you set the thumbwheel of an input module to the I/O-MAP address = 01, the register assignment is 30010.

Table 9-5 Setting the white thumbwheel for register 30010 (read)

Read register	I/O-MAP address (white thumbwheel)	Consecutive number 0 ... 9
30	**01**	**0**

9.5 Modbus memory map

The I/O data from the extension modules is stored in an internal register, the Modbus memory map. In PLC/Modbus RTU mode, the Modbus memory map is contained in the master wireless module with the RAD ID = 01. In PLC/Modbus RTU dual mode, the Modbus memory map is contained within each wireless module. The data contained can be read or written by a Modbus master.

The following process data tables for the individual extension modules show at what position the I/O data is stored in the Modbus memory map. You can find a complete overview of the Modbus memory map from page 79 onwards.

The RSSI signal register can be found starting on page 83.

9.5.1 RAD-AI4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AI4-IFS	20_{hex}	06_{hex}	30xx0 ... 30xx5[1]	fc 04

1 xx = I/O-MAP address set using the thumbwheel

30xx1	**Reserved**

30xx2				**Analog input 1 (terminal point 2.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI1															

30xx3				**Analog input 2 (terminal point 3.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI2															

30xx4				**Analog input 3 (terminal point 4.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI3															

30xx5				**Analog input 4 (terminal point 5.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI4															

30xx6 ... 30xx9	**Reserved**

9.5.2 RAD-PT100-4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-PT100-4-IFS	21_{hex}	06_{hex}	30xx0 ... 30xx5[1]	fc 04

[1] xx = I/O-MAP address set using the thumbwheel

30xx1	**Reserved**

30xx2				**Pt 100 input 1 (terminal point 2.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T1															

30xx3				**Pt 100 input 2 (terminal point 3.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T2															

30xx4				**Pt 100 input 3 (terminal point 4.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T3															

30xx5				**Pt 100 input 4 (terminal point 5.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T4															

30xx6 ... 30xx9	**Reserved**

9.5.3 RAD-AO4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AO4-IFS	30_{hex}	06_{hex}	40xx0 ... 40xx5[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

40xx1	Reserved

40xx2				Analog output 1 (terminal point 2.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO1															

40xx3				Analog output 2 (terminal point 3.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO2															

40xx4				Analog output 3 (terminal point 4.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO3															

40xx5				Analog output 4 (terminal point 5.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO4															

40xx6 ... 40xx9	Reserved

9.5.4 RAD-DI4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI4-IFS	01_{hex}	02_{hex}	30xx0 ... 30xx1[1]	fc 04

1 xx = I/O-MAP address set using the thumbwheel

30xx1				**Digital inputs**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
												DI4	DI3	DI2	DI1
Terminal point															
												6.x	5.x	2.x	1.x

30xx2 ... 30xx9	**Reserved**

9.5.5 RAD-DI8-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI8-IFS	02_{hex} Static mode	02_{hex} Static inputs	30xx0 ... 30xx1[1]	fc 04
	40_{hex} Pulse counter mode	06_{hex} Pulse inputs	30xx0 ... 30xx5[1]	fc 04
	40_{hex} Pulse counter mode	02_{hex} Reset counter states	40xx0 ... 40xx1[1]	fc 03, 16

1 xx = I/O-MAP address set using the thumbwheel

30xx1				Digital inputs DI1 ... DI8 (static mode)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
								DI8	DI7	DI6	DI5	DI4	DI3	DI2	DI1
Terminal point															
								5.x	5.x	4.x	4.x	3.x	3.x	2.x	2.x

30xx2				DI1: 32-bit pulse input, pulse counter mode (terminal point 2.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Counter state DI1, low word															

30xx3				DI1: 32-bit pulse input, pulse counter mode (terminal point 2.x)											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Counter state DI1, high word															

30xx4				DI7: 32-bit pulse input, pulse counter mode (terminal point 5.x)											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Counter state DI7, low word															

30xx5				DI7: 32-bit pulse input, pulse counter mode (terminal point 5.x)											
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Counter state DI7, high word															

30xx6 ... 30xx9	Reserved

40xx1				Reset of counter states DI1/DI7											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														X[1]	X[2]

[1] **Bit 1 = 1:** counter state DI7 reset to 0

[2] **Bit 0 = 1:** counter state DI1 reset to 0

40xx2 ... 40xx9	Reserved

9.5.6 RAD-DOR4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DOR4-IFS	10_{hex}	02_{hex}	40xx0 ... 40xx1[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

40xx1				**Digital outputs**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
												DO 4	DO 3	DO 2	DO 1
Terminal point															
												6.x	5.x	2.x	1.x

40xx2 ... 40xx9	**Reserved**

9.5.7 RAD-DO8-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DO8-IFS	11_{hex}	02_{hex} Outputs	40xx0 ... 40xx1[1]	fc 03.16
		02_{hex} Short-circuit detection	30xx0 ... 30xx1[1]	fc 04

[1] xx = I/O-MAP address set using the thumbwheel

30xx1				Short-circuit detection at the digital outputs											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Reserved														X[1]	X[2]

[1] **Bit 1 = 1:** Short circuit detected at one or several outputs 5 ... 8.

[2] **Bit 0 = 1:** Short circuit detected at one or several outputs 1 ... 4.

30xx2 ... 30xx9	Reserved

40xx1				Digital outputs DO1 ... DO8											
Channel (high byte)								Channel (low byte)							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Reserved								DO 8	DO 7	DO 6	DO 5	DO 4	DO 3	DO 2	DO 2
Terminal point															
								5.x	5.x	4.x	4.x	3.x	3.x	2.x	2.x

40xx2 ... 40xx9	Reserved

9.5.8 RAD-DAIO6-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DAIO6-IFS	60_{hex}	03_{hex} (inputs)	30xx0 ... 30xx2[1]	fc 04
		03_{hex} (outputs)	40xx0 ... 40xx2[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

30xx1				**Digital inputs**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														DI2	DI1
Terminal point															
														2.x	1.x

30xx2				**Analog input (terminal point 3.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI1															

30xx3 ... 30xx9	**Reserved**

40xx1				**Digital outputs**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														DO 2	DO 1
Terminal point															
														6.x	5.x

40xx2				**Analog output (terminal point 4.x)**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO1															
Terminal point															
															4.x

40xx3 ... 40xx9	**Reserved**

9.5.9 Complete overview of the Modbus memory map

I/O input data, address area 30010 ... 30999,
Modbus function code 04

RAD-DAIO6-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1															DI	
																	2	1
																	X	X
30	xx	2	AI1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30xx3 ... 30xx9 reserved																		

I/O output data, address area 40010 ... 40999
Modbus function code 03, 16

RAD-DAIO6-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1															DO	
																	2	1
																	X	X
40	xx	2	AO1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40xx3 ... 40xx9 reserved																		

RAD-DI4-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1													DI4 ... DI1			
															X	X	X	X
30xx2 ... 30xx9 reserved																		

RAD-DOR4-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1													DO4 ... DO1			
															X	X	X	X
40xx2 ... 40xx9 reserved																		

RAD-DI8-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1									DI8 ... DI1							
											X	X	X	X	X	X	X	X
30	xx	2	Counter state DI1 (low word)															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	3	Counter state DI1 (high word)															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	4	Counter state DI7 (low word)															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	5	Counter state DI7 (high word)															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30xx6 ... 30xx9 reserved																		

RAD-DI8-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1	Bit 0 = 1: Reset DI1 Bit 1 = 1: Reset DI7															
																	X	X
40xx2 ... 40xx9 reserved																		

I/O input data, address area 30010 ... 30999

Modbus function code 04

RAD-DO8-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1	Short-circuit detection Bit 0: DO 1 ... 4, Bit 1: 5 ... 8															
																	X	X
30xx2 ... 30xx9 reserved																		

I/O output data, address area 40010 ... 40999

Modbus function code 03, 16

RAD-DO8-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1								DO								
										9	8	7	6	5	4	3	2	1
										X	X	X	X	X	X	X	X	X
40xx2 ... 40xx9 reserved																		

RAD-AI4-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1	Reserved															
30	xx	2	AI1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	3	AI2															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	4	AI3															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	5	AI4															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30xx6 ... 30xx9 reserved																		

RAD-AO4-IFS

	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1	Reserved															
40	xx	2	AO1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	3	AO2															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	4	AO3															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	5	AO4															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40xx6 ... 40xx9 reserved																		

I/O input data, address area 30010 ... 30999 Modbus function code 04																		
RAD-PT100-4-IFS																		
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1	Reserved															
30	xx	2	T1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	3	T2															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	4	T3															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	5	T4															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30xx6 ... 30xx9 reserved																		

Example for reading the temperature T1 (I/O-MAP = 02):
function code 04, start address 21 (hex15)

....

....

30	99	0																

I/O output data, address area 40010 ... 40999 Modbus function code 03, 16

....

....

40	99	0																

RSSI signals - address area 35001 ... 35250, function code 04

	RAD ID	15...4	3	2	1	0	Bit
35	001						RSSI: RAD ID = 01 - Master
	.						RSSI: RAD ID = 02
	.						RSSI: RAD ID = 03
	.						...
35	250						RSSI: RAD ID = 250

Example for reading an RSSI register of the station with RAD ID = 02:
function code 04, start address 5001 (hex1389)

9.6 Error codes and formats for analog input and output values

The measured value is represented in bits 0 ... 15. Values higher than 8000_{hex} indicate an error.

Analog RAD-AI4-IFS inputs

Table 9-6 Representation of analog RAD-AI4-IFS values

Data word			
hex	**dec / error code**	**0 mA ... 20 mA**	**4 mA ... 20 mA**
0000	0	0 mA	-
1770	6000	4 mA	4 mA
7530	30000	20 mA	20 mA
7F00	32512	21.67 mA	21.67 mA
8001	Overrange	>21.67 mA	>21.67 mA
8002	Open circuit	-	<3.2 mA
8080	Underrange	< 0 mA	-

Analog RAD-AO4-IFS outputs

Table 9-7 Representation of analog RAD-AO4-IFS values

Data word			
hex	**dec / error code**	**0 mA ... 20 mA**	**0 V ... 10 V**
0000	0	0 mA	0 V
7530	30000	20 mA	10 V
7F00	32512	21.67 mA	10.84 V

Analog RAD-DAIO6-IFS inputs and outputs

Table 9-8 Representation of analog RAD-DAIO6-IFS values

Data word				
hex	**dec / error code**	**0 ... 20 mA**	**4 ... 20 mA**	**0 V ... 10 V**
0000	0	0 mA	-	0 V
1770	6000	4 mA	4 mA	2 V
7530	30000	20 mA	20 mA	10 V
7F00	32512	21.67 mA	21.67 mA	10.84 V
8001	Overrange	>21.67 mA	>21.67 mA	-
8002	Open circuit	-	<3.2 mA	-
8080	Underrange	< 0 mA	-	-

Error codes and formats for Pt 100 values

Table 9-9 Representation of the RAD-PT100-4-IFS Pt 100 values

Data word		RAD-PT100-4-IFS Pt 100 input	RAD-AO4-IFS analog output		
hex	**dec / error code**	**-50°C ... +250°C**	**0 mA ... 20 mA**	**0 V ... 10 V**	**Possible cause**
0000	0	-50°C	0 mA	0 V	
7530	30000	+250°C	20 mA	10 V	
7F00	32512	+275.12°C	21.67 mA	10.84 V	
8001	Overrange				
8002	Open circuit				Sensor wired incorrectly, measuring line too long, cable resistance too high
8080	Underrange				

9.7 RSSI signal register

The RSSI values indicate the received signal strength on the wireless module. In both PLC/Modbus RTU and PLC/Modbus RTU dual modes, you can read the RSSI values via the serial interface of the master wireless module (RAD ID = 01) using Modbus/RTU commands. The RSSI values of all wireless modules are within the address area 35001 ... 35250.

Table 9-10 RSSI signal register

Address area		**35001 ... 35250**															
Modbus function code		**fc 04**															
Address	Wireless module	High byte								Low byte, RSSI value							
		15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
35001	RSSI - RAD ID = 1 (master)	Reserved								X	X	X	X	X	X	X	X
35002	RSSI - RAD ID = 2	Reserved								X	X	X	X	X	X	X	X
...	...	Reserved								X	X	X	X	X	X	X	X
35250	RSSI - RAD ID = 250	Reserved								X	X	X	X	X	X	X	X

- Bits 8 ... 15 are reserved.
- Values < 255 indicate the RSSI value in -dBm.
- The value 255 means that the RSSI value is invalid or the device cannot be reached.

Example for reading the RSSI register of the station with RAD ID = 2:
function code 04, start address 5001 (hex1389)

In PLC/Modbus RTU dual mode, the RSSI value is also within the register 35000 of each wireless module, since each one has its own Modbus address.

10 Description of I/O extension modules

10.1 RAD-AI4-IFS - analog extension module with four inputs

The analog RAD-AI4-IFS I/O extension module can process up to four input signals between 0/4 mA ... 20 mA. All inputs are electrically isolated from one another, from the supply voltage, and from the electronics.

A supply voltage of 12 V DC, minimum, is available at the PWR_1 connection terminal block for passive sensors (see Figure 10-1, item 1).

10.1.1 Structure

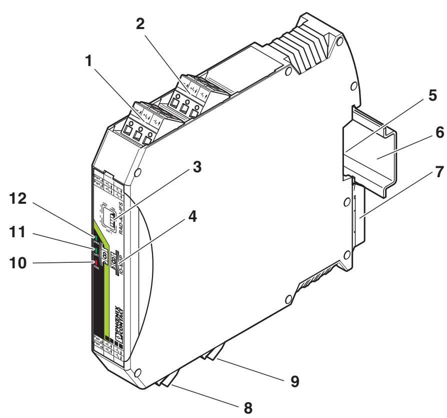


Figure 10-1 RAD-AI4-IFS structure

Item	Designation
1	Analog input 2 for 2-, 3-, 4-wire measuring transducers
2	Analog input 1 for 2-, 3-, 4-wire measuring transducers
3	DIP switches for configuring the analog inputs (current/voltage input)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Analog input 3 for 2-, 3-, 4-wire measuring transducers
9	Analog input 4 for 2-, 3-, 4-wire measuring transducers
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

10.1.2 Basic circuit diagram

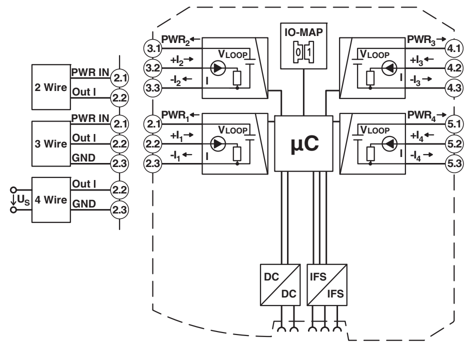


Figure 10-2 Basic circuit diagram for the RAD-AI4-IFS

10.1.3 Setting the DIP switches

Using the DIP switches on the front, you can configure the inputs signals (0 mA ... 20 mA or 4 mA ... 20 mA). Any changes in the setting of the DIP switches will be directly applied.

In PLC/Modbus RTU mode, the setting of the input signals is evaluated for error diagnostics. With the setting 4 mA ... 20 mA, it is, for example, possible to detect an open circuit.

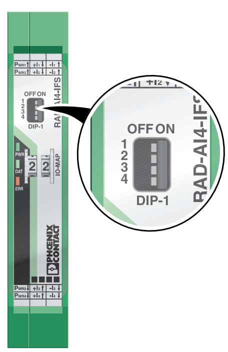


Figure 10-3 DIP switches of the RAD-AI4-IFS

Table 10-1 DIP switches of the RAD-AI4-IFS

		DIP switch			
Setting	**Input signal**	**1**	**2**	**3**	**4**
Analog IN1	0 mA ... 20 mA	OFF			
Analog IN1	4 mA ... 20 mA	ON			
Analog IN2	0 mA ... 20 mA		OFF		
Analog IN2	4 mA ... 20 mA		ON		
Analog IN3	0 mA ... 20 mA			OFF	
Analog IN3	4 mA ... 20 mA			ON	
Analog IN4	0 mA ... 20 mA				OFF
Analog IN4	4 mA ... 20 mA				ON

10.1.4 Diagnostic LEDs

The RAD-AI4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

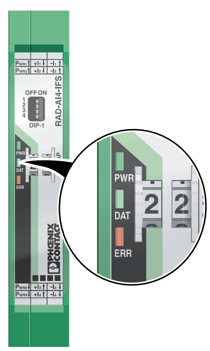


Figure 10-4 Diagnostic LEDs of the RAD-AI4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	No bus communication
ON	Critical internal error

10.1.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-2 Setting the I/O-MAP address for the RAD-AI4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.1.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section 10.1, “RAD-AI4-IFS - analog extension module with four inputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AI4-IFS	20_{hex}	06_{hex}	30xx0 ... 30xx5	fc 04

10.2 RAD-PT100-4-IFS - extension module with four temperature inputs

> Use the I/O extension modules in connection with the RAD-900-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.
>
> The firmware and software can be found on the Internet at phoenixcontact.net/products.

The analog RAD-PT100-4-IFS I/O extension module has four Pt 100 inputs for temperatures between -50°C ... +250°C. The Pt 100 inputs T1 ... T4 can be mapped to the analog outputs I1/U1 ... I4/U4 of the RAD-AO4-IFS extension module. All the inputs are electrically isolated from one another, from the supply voltage, and from the remaining electronics.

Pt 100 resistance thermometers can be connected to the RAD-PT100-4-IFS I/O extension module. The thermometers change their resistance depending on the temperature. The Pt 100 input signals are acquired by the RAD-PT100-4-IFS and can be mapped to proportional, analog voltage or current signals of the RAD-AO4-IFS output module.

Example: At the Pt 100 input, a current of 0 mA or a voltage of 0 V is released at the output module at a temperature of -50°C. At the Pt 100 input, a current of 20 mA or a voltage of 10 V is released at the output at a temperature of 250°C.

Pt 100 input	Analog output
-50°C	0 mA or 0 V
+250°C	20 mA or 10 V

10.2.1 Connecting sensors

You can connect 2-wire or 3-wire sensors to the extension module. Observe the measuring errors depending on the different measuring methods.

2-wire connection technology

2-wire connection technology is the most cost-effective connection method. The temperature-related voltage is not directly measured at the sensor and therefore falsified by the two cable resistances R_L. The measuring errors that occur may lead to the entire measurement to become useless. Please observe the diagrams in Section "Measuring errors using 2-wire connection technology" on page 91.

With 2-wire technology, you need an insertion bridge between terminals x.2 and x.3.

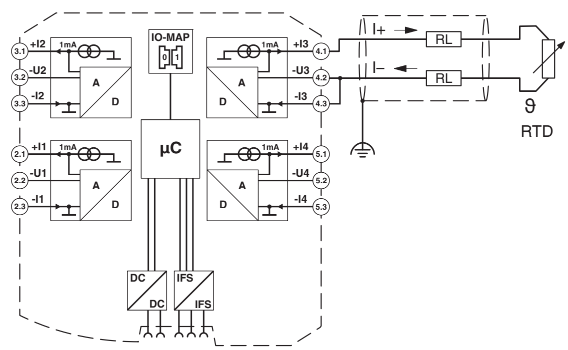


Figure 10-5 2-wire connection technology

3-wire connection technology

With 3-wire connection technology, the temperature-related voltage is measured several times. Corresponding calculations additionally reduce the effect of the cable resistance on the measurement result. The results are almost as good as those achieved using the 4-wire technology.

The cable resistances R_L at the terminals +I and -I must have the same value. This allows you to subtract the established cable resistance from the measurement result and to get the Pt 100 platinum resistance value.

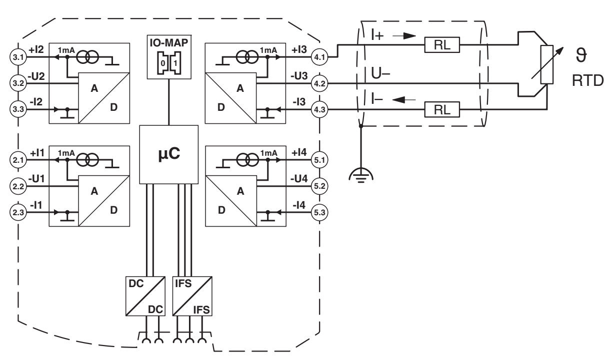


Figure 10-6 3-wire connection technology

4-wire connection technology

The RAD-PT100-4-IFS does not support the 4-wire connection technology.

- If you want to use a 4-wire sensor, only connect three of the four wires.
- The fourth wire should be left unwired. Otherwise there will be a different resistance in the +I and -I cables owing to the parallel connection of two cable resistances.

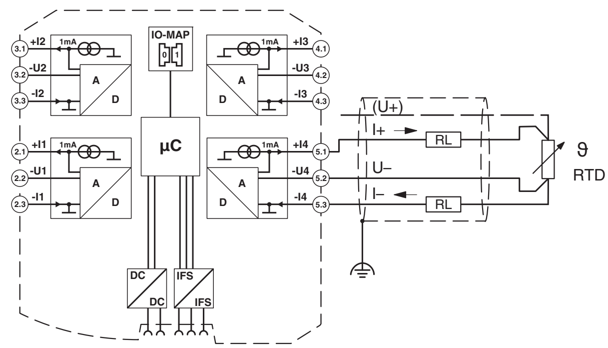


Figure 10-7 4-wire connection technology

10.2.2 Measuring errors using 2-wire connection technology

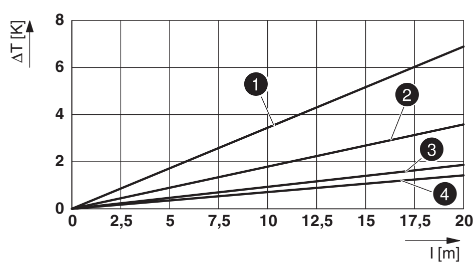


Figure 10-8 Systematic temperature measuring error ΔT depending on the cable length l

Curves depending on cable cross section A

1 Temperature measuring error for A = 0.25 mm^2

2 Temperature measuring error for A = 0.5 mm^2

3 Temperature measuring error for A = 1.0 mm^2

4 Temperature measuring error for A = 1.5 mm^2

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C and Pt 100 sensor)

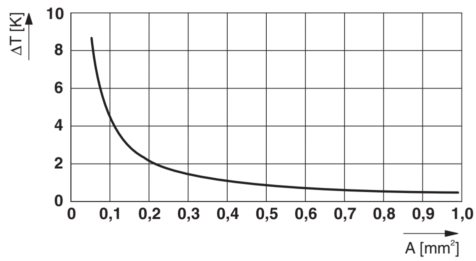


Figure 10-9 Systematic temperature measuring error ΔT depending on the cable cross section A

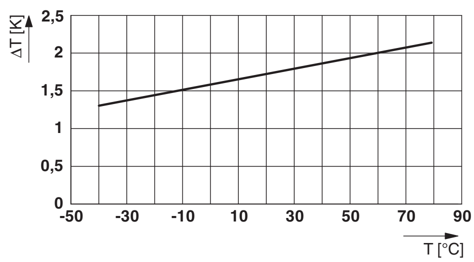


Figure 10-10 Systematic temperature measuring error ΔT depending on the cable temperature T_A

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C and Pt 100 sensor)

Make sure that the cable resistance and therefore the measuring error is as low as possible.

- Use sensor cables that are as short as possible.
- Avoid conductor cross sections smaller than 0.5 mm^2.

The temperature has only a small influence on the cable resistance.

You can calculate the cable resistance as follows:

$$R_L = R_{L20} \times [1 + 0.0039 \frac{1}{K} \times (T_A - 20°C)]$$

$$R_L = \frac{l}{\chi \times A} \times [1 + 0.0039 \frac{1}{K} \times (T_A - 20°C)]$$

R_L	Cable resistance in Ω
R_{L20}	Cable resistance at 20°C in Ω
l	Line length in m
χ	Specific resistance of copper in m/Ωmm^2
A	Cable cross section in mm^2
0.0039 1/K	Temperature coefficient for copper (degree of purity of 99.99%)
T_A	Ambient temperature (cable temperature) in °C

Due to there being two cable resistances in the measuring system, the value must be doubled. Using the average temperature coefficient α = 0.385 Ω/K for Pt 100, the absolute measuring error in Kelvin can be determined for platinum sensors according to DIN standards.

10.2.3 Shielding of the sensor cables

Always connect the analog sensors using shielded, twisted pair cables (e.g., LiYCY, TP 2 x 2 x 0.5 mm^2).

- Immediately following entry in the control cabinet, connect the cable shields to the corresponding shield connection clamps.

> Please note that the electrical isolation between the channels may no longer occur when connecting the shields. The isolating distances between the individual channels need to be re-evaluated after connecting the shields. The distances between the individual wires and the common shields are crucial in this respect.

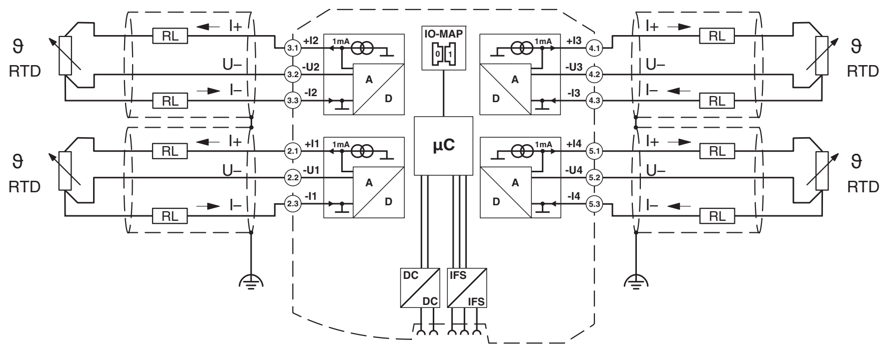


Figure 10-11 Shielding with 3-wire connection technology

2-wire connection technology with twisted pair cables and shielding

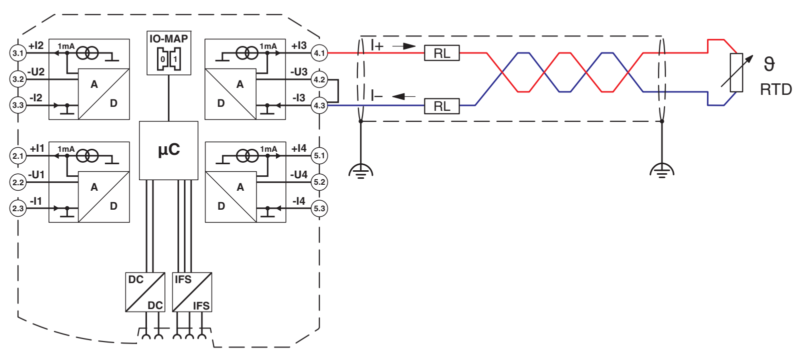


Figure 10-12 2-wire connection technology with twisted pair cables and shielding

3-wire connection technology with twisted pair cables and shielding

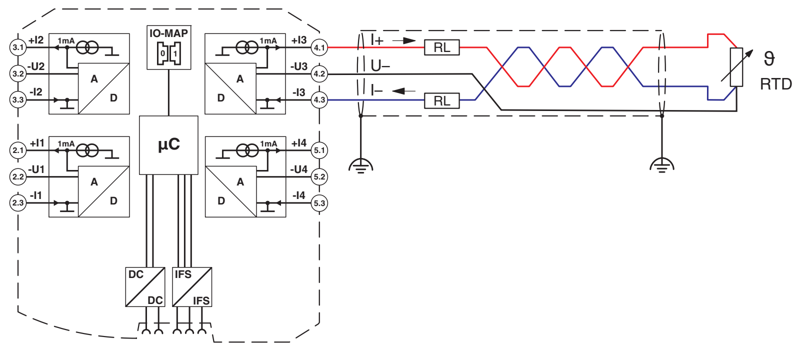


Figure 10-13 3-wire connection technology with twisted pair cables and shielding

10.2.4 Structure

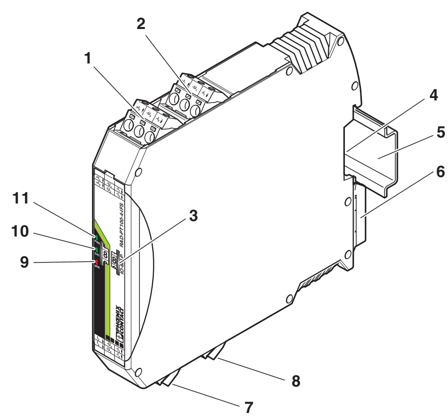


Figure 10-14 RAD-PT100-4-IFS structure

Item	Designation
1	Pt 100 input 2 for 2- and 3-wire sensors
2	Pt 100 input 1 for 2- and 3-wire sensors
3	White thumbwheel for setting the I/O-MAP address
4	Connection option for DIN rail connector
5	DIN rail
6	Metal foot catch for DIN rail fixing
7	Pt 100 input 3 for 2- and 3-wire sensors
8	Pt 100 input 4 for 2- and 3-wire sensors
9	ERR status LED, red (communication error)
10	DAT status LED, green (bus communication)
11	PWR status LED, green (supply voltage)

10.2.5 Basic circuit diagram

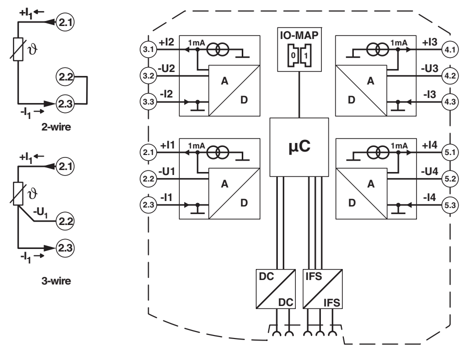


Figure 10-15 Basic circuit diagram for the RAD-PT100-4-IFS

> With 2-wire technology, you need an insertion bridge between terminals x.2 and x.3. In this case, the measuring accuracy is reduced (see “Measuring errors using 2-wire connection technology” on page 91).

10.2.6 Diagnostic LEDs

The RAD-PT100-4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

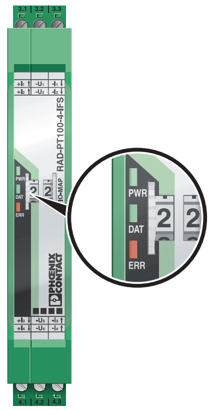


Figure 10-16 Diagnostic LEDs of the RAD-PT100-4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF		No error
Flashing		
	Slow (1.4 Hz)	I/O-MAP address changed
	Fast (2.8 Hz)	No bus communication
ON		Critical internal error

10.2.7 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-3 Setting the I/O-MAP address for the RAD-PT100-4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.2.8 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section 10.2, “RAD-PT100-4-IFS - extension module with four temperature inputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-PT100-4-IFS	21_{hex}	06_{hex}	30xx0 ... 30xx5	fc 04

10.3 RAD-AO4-IFS - analog extension module with four outputs

Using the analog RAD-AO4-IFS I/O extension module, up to four signals between 0/4 mA ... 20 mA can be output. All the outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

Use either the current or voltage output per analog channel.

10.3.1 Structure

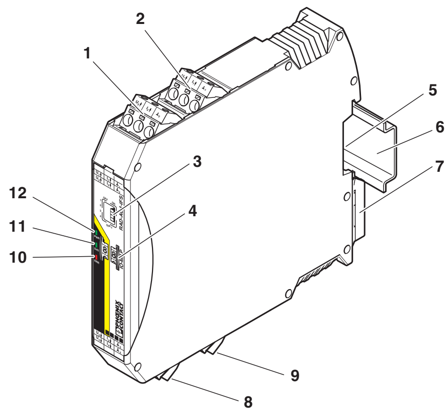


Figure 10-17 RAD-AO4-IFS structure

Item	Designation
1	Analog output 2 (alternatively current or voltage)
2	Analog output 1 (alternatively current or voltage)
3	DIP switches for configuring the outputs (current/voltage output)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Analog output 3 (alternatively current or voltage)
9	Analog output 4 (alternatively current or voltage)
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

10.3.2 Basic circuit diagram

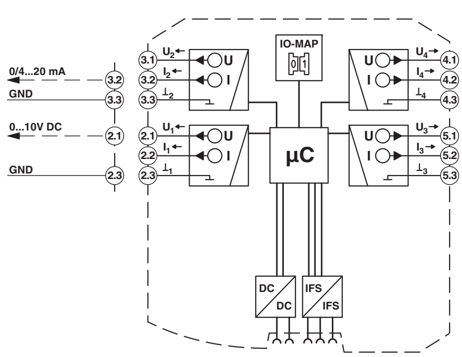


Figure 10-18 Basic circuit diagram for the RAD-AO4-IFS

10.3.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last valid output value

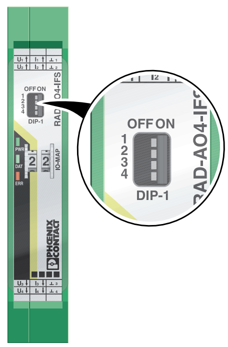


Figure 10-19 DIP switches of the RAD-AO4-IFS

Table 10-4 DIP switches of the RAD-AO4-IFS

		DIP switch			
Input	**Output signal**	**1**	**2**	**3**	**4**
Analog OUT1	RESET	OFF			
Analog OUT1	HOLD	ON			
Analog OUT2	RESET		OFF		
Analog OUT2	HOLD		ON		
Analog OUT3	RESET			OFF	
Analog OUT3	HOLD			ON	
Analog OUT4	RESET				OFF
Analog OUT4	HOLD				ON

10.3.4 Diagnostic LEDs

The RAD-AO4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

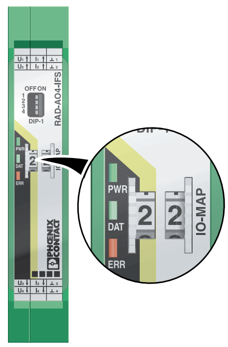


Figure 10-20 Diagnostic LEDs of the RAD-AO4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF		No error
Flashing		
	Slow (1.4 Hz)	I/O-MAP address changed
	Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON		Critical internal error

10.3.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-5 Setting the I/O-MAP address for the RAD-AO4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.3.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section 10.3, “RAD-AO4-IFS - analog extension module with four outputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AO4-IFS	30_{hex}	06_{hex}	40xx0 ... 40xx5	fc 03, 16

10.4 RAD-DI4-IFS - digital extension module with four inputs

WARNING: Risk of electric shock
Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The digital RAD-DI4-IFS I/O extension module can process up to four input signals. The digital inputs process voltages between 0 V ... 50 V AC/DC at the low-voltage input and voltages between 0 V ... 250 V AC/DC at the high-voltage input. All inputs are electrically isolated from one another, from the supply voltage, and from the electronics.

10.4.1 Structure

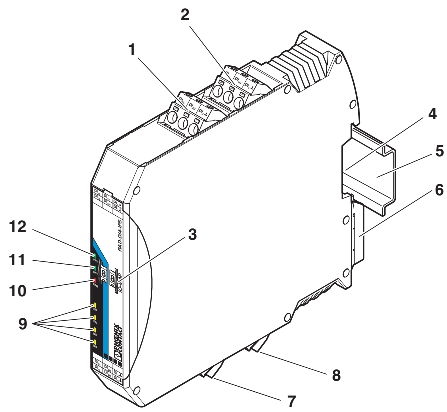


Figure 10-21 RAD-DI4-IFS structure

Item	Designation
1	Digital input as wide-range input
2	Digital input as wide-range input
3	White thumbwheel for setting the I/O-MAP address
4	Connection option for DIN rail connector
5	DIN rail
6	Metal foot catch for DIN rail fixing
7	Digital input as wide-range input
8	Digital input as wide-range input
9	Status LEDs for digital inputs DI1 ... DI4
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

10.4.2 Basic circuit diagram

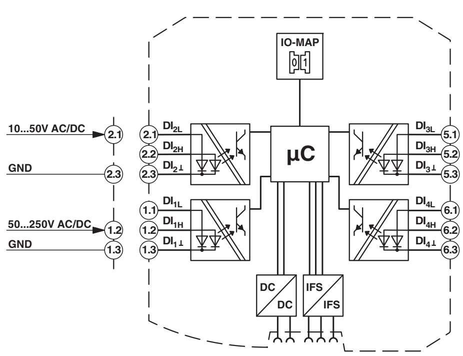


Figure 10-22 Basic circuit diagram for the RAD-DI4-IFS

10.4.3 Diagnostic LEDs

The RAD-DI4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

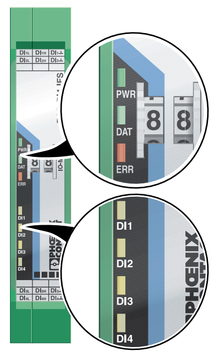


Figure 10-23 Diagnostic LEDs of the RAD-DI4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding output module has not been found.

OFF		No error
Flashing		
	Slow (1.4 Hz)	I/O-MAP address changed
	Fast (2.8 Hz)	No bus communication
ON		Critical internal error

DI1 ... DI4

The yellow DI1 ... DI4 LEDs indicate the status of the digital inputs.

10.4.4 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-6 Setting the I/O-MAP address for the RAD-DI4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.4.5 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For additional information, please refer to Section 10.4, “RAD-DI4-IFS - digital extension module with four inputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI4-IFS	01_{hex}	02_{hex}	30xx0 ... 30xx1	fc 04

10.5 RAD-DI8-IFS - digital extension module with eight inputs

Use the I/O extension modules in connection with the RAD-900-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

The digital RAD-DI8-IFS I/O extension module can process up to eight digital input signals or two pulse signals. You can use DIP switch 1 to set the operating mode. For more detailed information on setting the DIP switch, please refer to page 106.

The eight digital inputs are arranged in two groups of four inputs each with a common reference potential (GND). The two DC groups are electrically isolated from one another, from the supply voltage, and from the electronics.

10.5.1 Structure

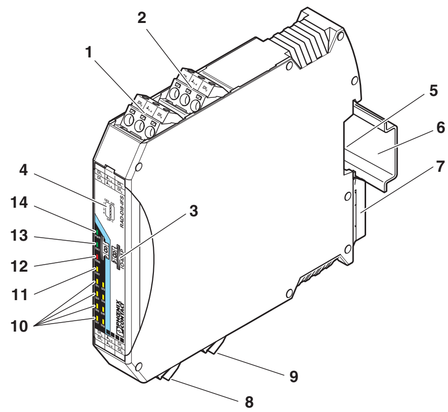


Figure 10-24 RAD-DI8-IFS structure

Item	Designation
1	Digital inputs 3 + 4
2	Digital inputs 1 + 2, DI1: pulse input 1
3	White thumbwheel for setting the I/O-MAP address
4	DIP switch for switching between static mode and pulse counter mode for digital inputs
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Digital inputs 5 + 6
9	Digital inputs 7 + 8, DI7: pulse input 2
10	Status LEDs for digital inputs DI1 ... DI8
11	CNT status LED, green (pulse counter mode)
12	ERR status LED, red (communication error)
13	DAT status LED, green (bus communication)
14	PWR status LED, green (supply voltage)

10.5.2 Basic circuit diagram

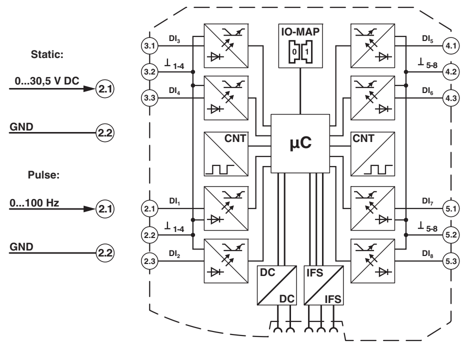


Figure 10-25 Basic circuit diagram for the RAD-DI8-IFS

10.5.3 Setting the DIP switches

You can use the DIP switches on the front to select between static mode or pulse counter mode.

– In static mode, the DI1 ... DI8 inputs are activated, 0 V ... 30.5 V DC voltage.
– In pulse counter mode, the DI1 and DI7 pulse inputs are activated, 0 Hz ... 100 Hz pulses.

> The pulse counter function is only available in PLC/Modbus RTU mode. Set the operating mode using the PSI-CONF software (from page 38 onwards).

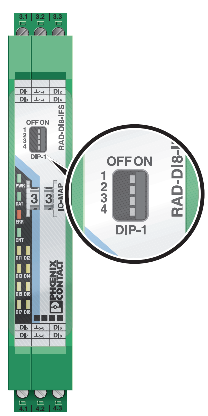


Figure 10-26 DIP switches of the RAD-DI8-IFS

Table 10-7 DIP switches of the RAD-DI8-IFS

		DIP switch			
Input	**Output signal**	**1**	**2**	**3**	**4**
Digital IN DI1 ... DI8	Static mode	OFF	n.c.	n.c.	n.c.
Counter IN DI1 + DI7	Pulse counter mode	ON	n.c.	n.c.	n.c.

n. c. = not connected, DIP switches 2 ... 4 have no function

- Use DIP switch 1 to select between static mode and pulse counter mode.
- Disconnect the device from the supply voltage.
- Switch the supply voltage back on.
- The selected mode is now active.

10.5.4 Functions in pulse counter mode

The counter state can only increase consecutively. When the maximum counter limit of 4,294,967,295 is reached, the counter is automatically set back to 0. In addition, you can manually reset the counter states in three different ways:

Reset counter state via power up

- Disconnect the device power supply and then reconnect the voltage.

Reset counter state via the Modbus RTU register

- Reset the counter states via Modbus RTU as follows:
  - DI1: bit 0 = 1 (register 40xx1)
  - DI7: bit 1 = 1 (register 40xx1)

Reset counter state by setting the inputs

- Set the corresponding input for at least 0.5 seconds:
  - Set the **DI3** input in order to reset the **DI1** counter state.
  - Set the **DI5** input in order to reset the **DI7** counter state.

10.5.5 Diagnostic LEDs

The RAD-DI8-IFS I/O extension module uses a total of twelve LEDs to indicate the operating states.

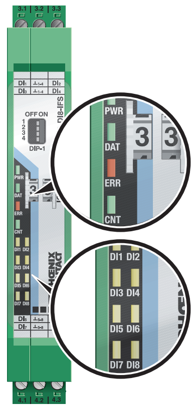


Figure 10-27 Diagnostic LEDs of the RAD-DI8-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF		No error
Flashing		
	Slow (1.4 Hz)	I/O-MAP address changed or mode switched using DIP switch 1, but not yet applied
	Fast (2.8 Hz)	No bus communication
ON		Critical internal error

CNT LED

The green CNT LED indicates that pulse counter mode is activated.

OFF	No error
Flashing	Mode switched using DIP switch 1, but not yet applied
ON	Pulse counter mode of digital inputs DI1 and DI7

DI1 ... DI8

The yellow DI1 ... DI8 LEDs indicate the status of the digital inputs.

In pulse counter mode: The DI1 and DI7 LEDs flash in time with the recorded pulses. The DI3 and DI5 LEDs light up when the counter state is reset.

DI3	ON (0.5 second)	Counter state DI1 reset to 0
DI5	ON (0.5 second)	Counter state DI7 reset to 0

10.5.6 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-8 Setting the I/O-MAP address for the RAD-DI8-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.5.7 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of eight data words. For additional information, please refer to Section 10.5, “RAD-DI8-IFS - digital extension module with eight inputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI8-IFS	02_{hex} Static mode	02_{hex} Static inputs	30xx0 ... 30xx1	fc 04
	40_{hex} Pulse counter mode	06_{hex} Pulse inputs	30xx0 ... 30xx5	fc 04
	40_{hex} Pulse counter mode	02_{hex} Reset counter states	40xx0 ... 40xx1	fc 03, 16

10.6 RAD-DOR4-IFS - digital extension module with four outputs

WARNING: Risk of electric shock

Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The digital RAD-DOR4-IFS I/O extension module can process up to four input signals that are switched via relay outputs. The digital outputs are designed as floating relay contacts (PDT). All outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

10.6.1 Structure

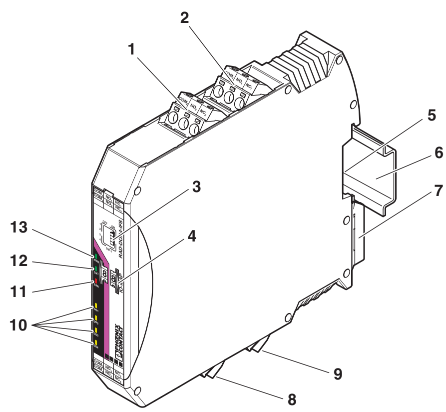


Figure 10-28 RAD-DOR4-IFS structure

Item	Designation
1	Relay output 2 with floating PDT contact
2	Relay output 1 with floating PDT contact
3	DIP switches for configuring the output behavior of the relay outputs (hold/reset)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Relay output 3 with floating PDT contact
9	Relay output 4 with floating PDT contact
10	Status LEDs for the relay outputs DO1 ... DO4
11	ERR status LED, red (communication error)
12	DAT status LED, green (bus communication)
13	PWR status LED, green (supply voltage)

10.6.2 Basic circuit diagram

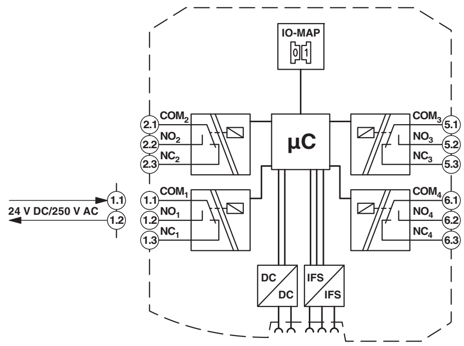


Figure 10-29 Basic circuit diagram for the RAD-DOR4-IFS

10.6.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last output value

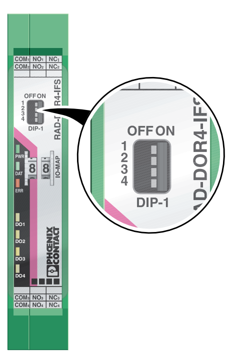


Figure 10-30 DIP switches of the RAD-DOR4-IFS

Table 10-9 DIP switches of the RAD-DOR4-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Digital OUT1	RESET	OFF			
Digital OUT1	HOLD	ON			
Digital OUT2	RESET		OFF		
Digital OUT2	HOLD		ON		
Digital OUT3	RESET			OFF	
Digital OUT3	HOLD			ON	
Digital OUT4	RESET				OFF
Digital OUT4	HOLD				ON

10.6.4 Diagnostic LEDs

The RAD-DOR4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

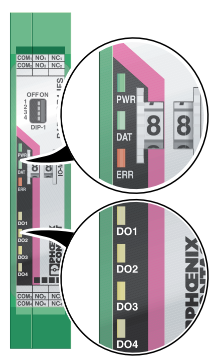


Figure 10-31 Diagnostic LEDs of the RAD-DOR4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF		No error
Flashing		
	Slow (1.4 Hz)	I/O-MAP address changed
	Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON		Critical internal error

DO1 ... DO4

The yellow LEDs DO1 ... DO4 LEDs indicate the status of the digital outputs.

10.6.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-10 Setting the I/O-MAP address for the RAD-DOR4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For additional information on process data, please refer to Section 10.6, “RAD-DOR4-IFS - digital extension module with four outputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DOR4-IFS	10_{hex}	02_{hex}	40xx0 ... 40xx1	fc 03, 16

10.7 RAD-DO8-IFS - digital extension module with eight outputs

> Use the I/O extension modules in connection with the RAD-900-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.
>
> The firmware and software can be found on the Internet at phoenixcontact.net/products.

The digital RAD-DO8-IFS I/O extension module processes up to eight digital output signals that are switched via transistor outputs. The eight outputs are arranged in two groups of four outputs each with a common electrical supply. The two output groups are electrically isolated from one another, from the supply voltage, and from the electronics.

Since the DO1 ... DO4 and DO5 ... DO8 output groups are electrically isolated, the digital outputs must be externally supplied (see Figure 10-33).

- The DO1 ... DO4 outputs are supplied via:
  - Terminal 1.1 (12 V DC ... 30.5 V DC)
  - Terminals 1.2/1.3 (GND)
- The DO5 ... DO8 outputs are supplied via:
  - Terminal 6.1 (12 V DC ... 30.5 V DC)
  - Terminals 6.2/6.3 (GND)

10.7.1 Structure

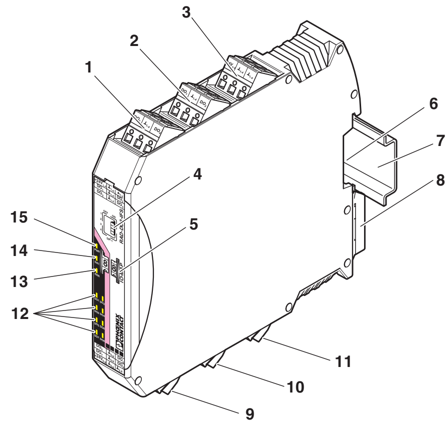


Figure 10-32 RAD-DO8-IFS structure

Item	Designation
1	Transistor outputs 3 + 4
2	Transistor outputs 1 + 2
3	Supply voltage for outputs 1 ... 4
4	DIP switches for setting the output behavior of the transistor outputs (hold/reset)
5	White thumbwheel for setting the I/O-MAP address
6	Connection option for DIN rail connector
7	DIN rail
8	Metal foot catch for DIN rail fixing
9	Transistor outputs 5 + 6
10	Transistor outputs 7 + 8
11	Supply voltage for outputs 5 ... 8
12	Status LEDs of transistor outputs DO1 ... DO8
13	ERR status LED, red (communication error)
14	DAT status LED, green (bus communication)
15	PWR status LED, green (supply voltage)

10.7.2 Basic circuit diagram

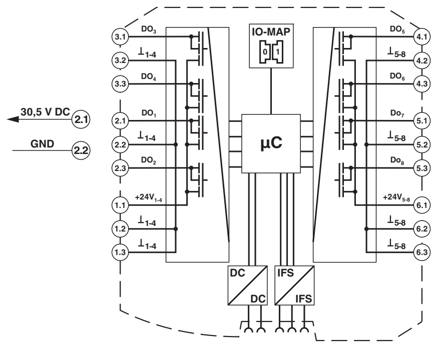


Figure 10-33 Basic circuit diagram for the RAD-DO8-IFS

10.7.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last output value

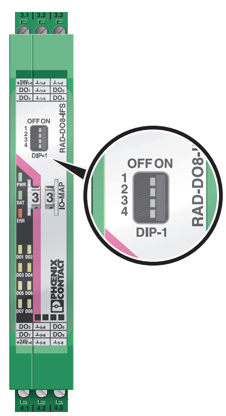


Figure 10-34 DIP switches of the RAD-DO8-IFS

Table 10-11 DIP switches of the RAD-DO8-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Digital OUT 1 ... 4	RESET	OFF		n. c.	n. c.
Digital OUT 1 ... 4	HOLD	ON		n. c.	n. c.
Digital OUT 5 ... 8	RESET		OFF	n. c.	n. c.
Digital OUT 5 ... 8	HOLD		ON	n. c.	n. c.

n. c. = not connected, DIP switches 3 and 4 have no function

10.7.4 Diagnostic LEDs

The RAD-DO8-IFS I/O extension module uses a total of eleven LEDs to indicate the operating states.

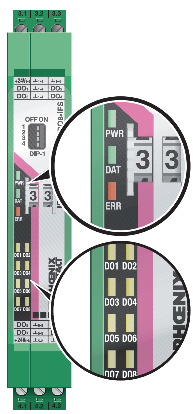


Figure 10-35 Diagnostic LEDs of the RAD-DO8-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF	No error
Flashing	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting) – Short circuit at one output or several outputs
ON	Critical internal error

DO1 ... DO8

The yellow DO1 ... DO8 LEDs indicate the status of the digital outputs.

DO1 ... DO4	Flashing	Short circuit at one output or several outputs 1 ... 4
DO5 ... DO8	Flashing	Short circuit at one output or several outputs 5 ... 8

10.7.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-12 Setting the I/O-MAP address for the RAD-DO8-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.7.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of four data words. For additional information, please refer to Section 10.7, “RAD-DO8-IFS - digital extension module with eight outputs”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DO8-IFS	11_{hex}	02_{hex} Outputs	40xx0 ... 40xx1	fc 03.16
		02_{hex} Short-circuit detection	30xx0 ... 30xx1	fc 04

10.8 RAD-DAIO6-IFS - analog/digital extension module with six channels

WARNING: Risk of electric shock
Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The analog/digital RAD-DAIO6-IFS I/O extension module has a total of six channels. The device is able to process two digital input and output signals as well as one analog input signal and one analog output signal. All inputs and outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

Two digital inputs

The digital inputs process voltages between 0 V ... 50 V AC/DC at the low-voltage input and 0 V ... 250 V AC/DC at the high-voltage input.

Two digital outputs

The digital outputs are designed as floating relay contacts (PDT). The switching capacity is 2 A at 250 V AC/24 V DC.

Analog input

The analog input is able to process standard signals between 0/4 mA ... 20 mA. A supply voltage of at least 12 V DC is available at the PWR_1 connection terminal block for the use of passive sensors.

Analog output

The analog output is designed as active output. You can either select a current signal 0/4 mA ... 20 mA or a voltage signal 0 V ... 10 V.

Use either a current or voltage output at the analog output.

10.8.1 Structure

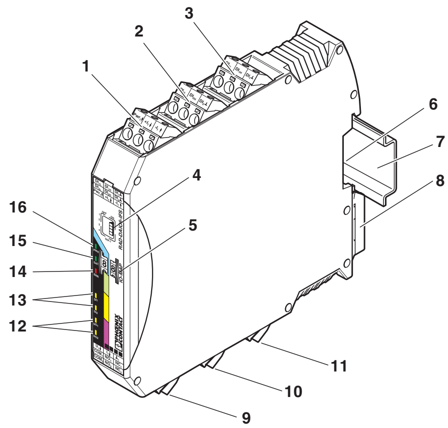


Figure 10-36 RAD-DAIO6-IFS structure

Item	Designation
1	Analog input for 2-, 3-, 4-wire measuring transducers
2	Digital input as wide-range input
3	Digital input as wide-range input
4	DIP switches for configuring the inputs and outputs
5	White thumbwheel for setting the I/O-MAP address
6	Connection option for DIN rail connector
7	DIN rail
8	Metal foot catch for DIN rail fixing
9	Analog output, alternatively current or voltage
10	Relay output with floating PDT contact
11	Relay output with floating PDT contact
12	Status LEDs of the digital DO1 ... DO2
13	Status LEDs of the digital DI1 ... DI2 inputs
14	ERR status LED, red (communication error)
15	DAT status LED, green (bus communication)
16	PWR status LED, green (supply voltage)

10.8.2 Basic circuit diagram

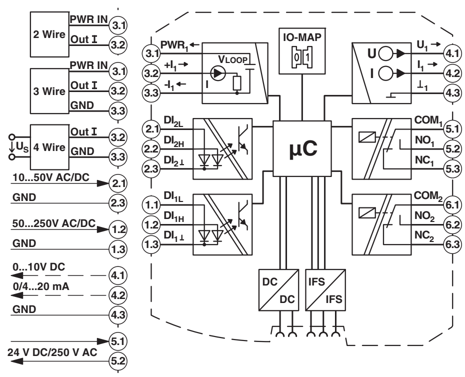


Figure 10-37 Basic circuit diagram for the RAD-DAIO6-IFS

10.8.3 Setting the DIP switches

The DIP switches on the front can be used to configure the input signals ranges. In addition, you can set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

Analog output

– RESET = Output value is set to 0
– HOLD = Hold last output value

Digital outputs

– RESET = Relay drops out
– HOLD = Hold last valid state

Figure 10-38 DIP switches of the RAD-DAIO6-IFS

Table 10-13 DIP switches of the RAD-DAIO6-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Analog IN	0 ... 20 mA	OFF			
Analog IN	4 ... 20 mA	ON			
Analog OUT	RESET		OFF		
Analog OUT	HOLD		ON		
Digital OUT1	RESET			OFF	
Digital OUT1	HOLD			ON	
Digital OUT2	RESET				OFF
Digital OUT2	HOLD				ON

10.8.4 Diagnostic LEDs

The RAD-DAIO6-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

Figure 10-39 Diagnostic-LEDs of the RAD-DAIO6-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding output module has not been found.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON	Critical internal error

DI1 / DI2

The yellow DI1 and DI2 LEDs indicate the status of the digital inputs.

DO1/DO2

The yellow DO1 and DO2 LEDs indicate the status of the digital outputs.

10.8.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 10-14 Setting the I/O-MAP address for the RAD-DAIO6-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

10.8.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section 10.8, “RAD-DAIO6-IFS - analog/digital extension module with six channels”.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DAIO6-IFS	60_{hex}	03_{hex} (inputs)	30xx0 ... 30xx2	fc 04
		03_{hex} (outputs)	40xx0 ... 40xx2	fc 03, 16

11 Planning wireless systems

11.1 Trusted Wireless 2.0

Phoenix Contact has developed Trusted Wireless 2.0 technology specifically for industrial applications. Trusted Wireless 2.0 operates in the license-free 900 MHz frequency band.

Features

- Rugged communication via the frequency hopping spread spectrum (FHSS)
- Automatic and manual mechanisms for coexistence with other systems transmitting in the same frequency band
- Secure data encryption and authentication
- Long range thanks to high receiver sensitivity and variable data transmission speed
- Flexible network structure with automatic connection management
- Distributed network management
- Comprehensive diagnostics options
- Adaptations to the required application are possible

Frequency hopping spread spectrum (FHSS) method

In the license-free 900 MHz frequency band, Trusted Wireless 2.0 uses the FHSS method. This method uses a selection of up to 127 channels from the entire spectrum of the frequency band. The wireless module “hops” between these channels on the basis of a pseudo-random pattern. This leads to a more robust and more reliable communication.

Coexistence management

Black listing means that certain frequencies can be hidden selectively. For example, this method allows you to operate several 900 MHz systems in parallel to Trusted-Wireless 2.0 systems without any performance limitations. In addition, different RF (Radio Frequency) bands are used, enabling the simultaneous use of several Trusted Wireless 2.0 systems.

Data encryption and authentication

Trusted Wireless 2.0 is a proprietary technology. The protocol has not been published. Therefore it is better protected against attacks. In addition, two security mechanisms have been implemented with 128-bit AES data encryption and authentication. The data encryption makes sure that intercepted data packets are not “understood”. The authentication process checks the sender’s authenticity. For this, a continuous code is added to the message, which must not be repeated. A manipulated message will be recognized as not valid and discarded.

Range

You can set the data rate of the wireless interface and adapt it to the respective application (16 kbps ... 500 kbps). By reducing the data rate, you can increase the sensitivity of the receiver and therefore the range. Distances from a few hundred meters to several kilometers can be covered using Trusted Wireless 2.0.

Network structures

Wireless modules can be used to create network structures with up to 250 devices. In this case, each device has a repeater function for forwarding data. In addition, the Trusted Wireless network is able to self-heal connection aborts (self-healing network). Alternative connection paths are initiated automatically. From a simple point-to-point connection to complex mesh networks, you can flexibly create various structures.

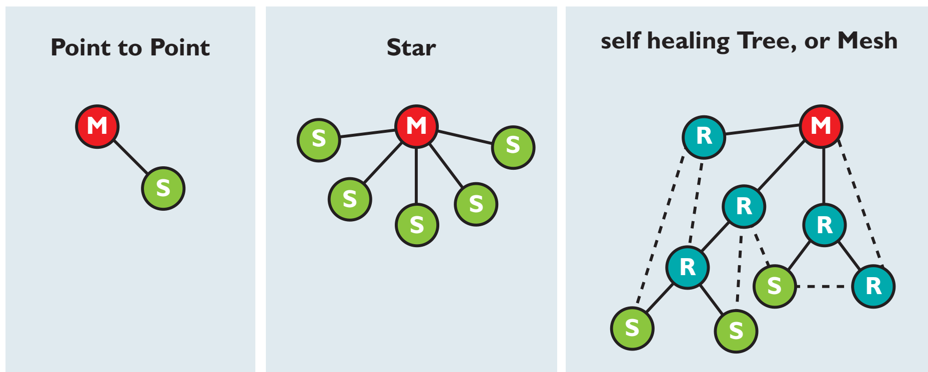


Figure 11-1 Point-to-point connection, star network, self-healing mesh network

Distributed network management

Technologies such as WirelessHART or ZigBee use a central network management. That means that all messages pass through a central manager, which can lead to significant volume of wireless network traffic.

Trusted Wireless 2.0, however, uses a distributed network management. For this purpose, “parent-child zones” are created in the wireless network, where the higher-level wireless module is referred to as the “parent” and the modules connected to it as “children”. All network management takes place within the parent-child zone and does not have to be directed through a central manager. This reduces the message traffic volume and accelerates the data exchange.

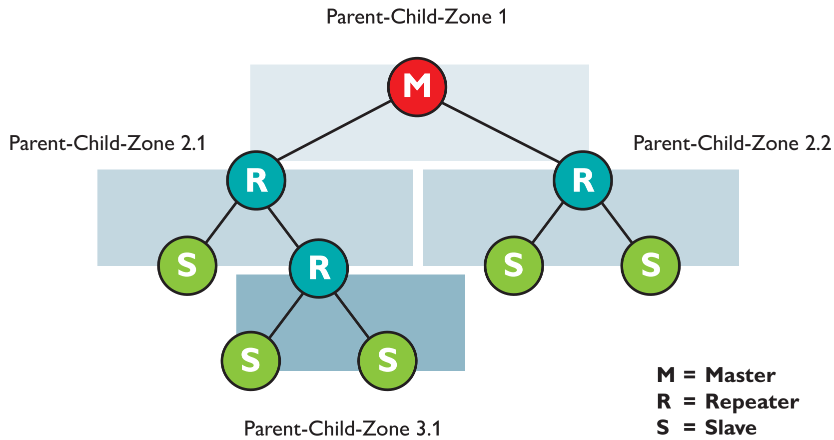


Figure 11-2 Distributed network management with parent-child zones

11.2 Planning wireless paths

When planning wireless paths over large distances, you need to consider height variations. A topographic map or a GPS device are very helpful in this regard. Using GPS devices, you can indicate variations in height and measure distances by means of way points. You can use the GPS devices as a direction indicator when later aligning the antennas.

Theoretical planning

The following questions should be taken into account when doing the theoretical planning:

- Which signals are to be transmitted?
- What points are the signals to be transmitted between?
- What is the distance between these points?
- Are there any topographic or structural obstacles?
- Are you able to circumnavigate these obstacles, e.g., by means of a repeater of higher mast?

When evaluating the data, you can carry out a system calculation to determine whether the wireless path is theoretically possible. You can find a calculation example from page 137 onwards.

Phoenix Contact recommends the use of the Wireless Network Planner software for determining feasibility of a wireless path. It can be downloaded for free at phoenixcontact.net/products

11.3 Practical test

To check the theoretical results, you should carry out an on-site practical test before purchasing a wireless system. Check the location for master, slave and repeater/slave modules on the basis of the following criteria in order to achieve the optimum wireless connection:

– Antenna is positioned ensuring a line of sight and a sufficient signal strength
– Primary power source for energy supply is available
– Protection of wireless modules against any influences of weather and extreme ambient conditions
– Adequate connections for antenna, surge protection, interface and other required cables

These requirements can be quickly assessed in most applications. However, it is often difficult to position the antenna. Of course, a connection path without any obstacles would be perfect. However, small obstacles in the Fresnel zone will not necessarily disturb communication. In general, obstacles on long wireless paths have a greater influence than on short ones.

11.4 Selecting antenna cables and antennas

Antenna cable

When installing a wireless system, it is very important that you use low-loss coaxial cables. Using an unsuitable cable may lead to considerable loss in performance which can neither be compensated by a high antenna gain nor by a high transmission power. For every 3 dB of coaxial cable loss, half the transmitter power will be lost before reaching the antenna. The received signal will also be reduced.

Consider the following factors when selecting the cable:

– Cable length to the antenna
– Acceptable signal loss
– Cable installation options

Antenna

Select the antenna depending on the application:

Application	Antenna
Short range and direct line of sight without any obstacles	Small omnidirectional antenna
Medium range	Large omnidirectional antenna (observe the vertical apex angle)
Wide range	Panel antenna (observe the horizontal apex angle)

For additional information on omnidirectional and panel antennas, please refer to the DB EN WIRELESS ACCESSORIES data sheet. The latest documentation can be downloaded at phoenixcontact.net/products.

11.5 Installing antennas

WARNING: Explosion hazard when used in potentially explosive areas
Observe the safety notes in “Safety regulations and installation notes” on page 13.

The following recommendations apply to all antenna installations:

Install the antenna in an open area as far away as possible from any obstacles such as buildings, dense deciduous forest or metal objects. Choose a location that provides a clear signal path in the direction of the opposite antenna. If two antennas are located in the same place, they should have a distance between them of at least 0.6 m in the vertical direction and 1 m in the horizontal direction.

Pay attention to antenna polarization. Most systems use a vertically polarized omnidirectional antenna at the master station. The opposite antennas must therefore also be polarized vertically. Vertical polarization means that the elements are aligned vertically to the horizon. Crossing polarization between the stations results in a signal loss of 20 dB, minimum.

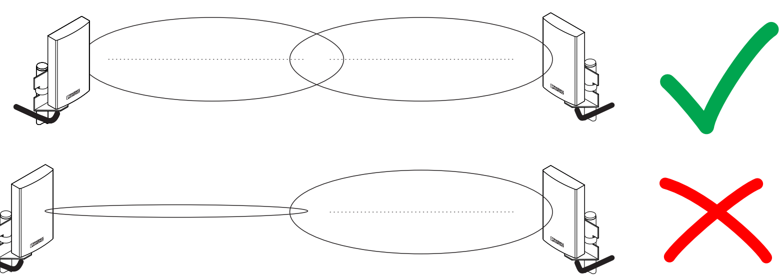


Figure 11-3 Antenna polarization

11.5.1 Aligning directional antennas

- First, align the antennas roughly. Use the following:
  - Topographic map
  - GPS device or compass
  - LED bar graph on the wireless module

Even if there is no direct line of sight, you can find the alignment point:

- Having carried out a rough alignment, you can now finely align the antenna via the RSSI voltage. Measure the RSSI voltage at the RSSI test socket of the wireless module (2.1/2.2) using a multimeter. For additional information on the RSSI voltage, please refer to page 46.
- You always have to align both antennas with each other, because the radio waves need to radiate into the antennas.
- In particular with regard to directional antennas, it is important to ensure that the antenna is properly fixed. If the antenna sways in the wind, the transmission or reception beam can move out of its target area.

11.6 Propagation of radio waves

In addition to the free space path loss, there are other factors which influence the wireless path. Dispersion, diffraction, and reflection represent types of interference that occur when the wireless signal encounters obstacles. They result in multipath propagation.

Dispersion

The dispersion of the wireless signal (e.g., at a tree) means that the wireless signal is dispersed in several directions. A tree without any leaves virtually allows all signals to completely pass through, whereas a tree with foliage results in a considerable degree of dispersion. The leaf surfaces disperse the wireless signal in all possible directions.

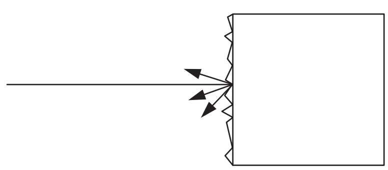


Figure 11-4 Dispersion on a rough surface

Diffraction

Diffraction of the wireless signal, e.g., on edges and obstacles, involves the signal being refracted around the edge. The signal then changes its direction. This is similar to the refraction of light in a crystal.

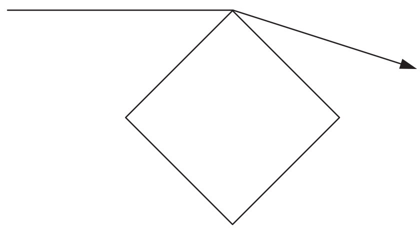


Figure 11-5 Diffraction on an edge

Reflection

Reflection on a smooth metal surface involves virtually the entire wireless signal being reflected at the same angle. In certain applications, the reflection may have a positive effect (e.g., if there is no line of sight). Reflections mainly occur in buildings.

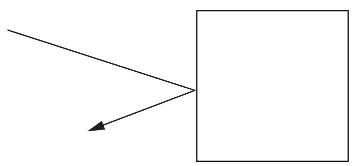


Figure 11-6 Reflection on a metal surface

Penetration

The type of wall encountered also influences the attenuation of the wireless signal. For example, the following constructions adversely affect the wireless signal:

– Hollow lightweight walls with aluminum-lined insulation
– False ceilings with metal or carbon fiber panels
– Lead glass
– Insulation glass (Thermopen)
– Glass with a metal coating
– Steel objects
– Fire walls
– Elevator shafts and stairwells

Each material has a different degree of attenuation. However, the following typical values provide a rough orientation.

Table 11-1 Attenuation with regard to different materials

Obstacle	Typical attenuation at 900 MHz [dB]
Thin wall	1 ... 3
Wooden wall	3
Brick wall	3 ... 7
Concrete wall	10 ... 20
Concrete ceiling	20
Elevator	20 ... 30

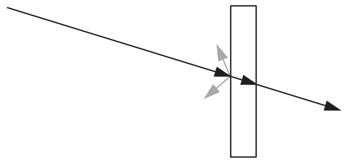


Figure 11-7 Reduction of radio waves when penetrating a wall

Also observe the angle between transmitter and receiver. Depending on the angle, the radio waves have to penetrate more or less material.

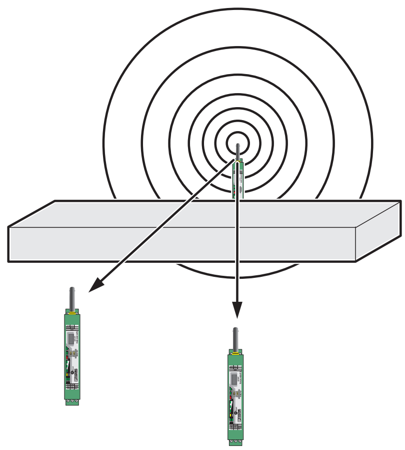


Figure 11-8 Angle of the transmitter and receiver

Radio dead spot

Radio dead spots are caused by impenetrable obstacles in the wireless path. The radio dead spot can be compared to the shadow cast by the sun. If the receiver is located in a radio dead spot, no direct radio waves can reach it, it can only receive reflections or diffracted waves.

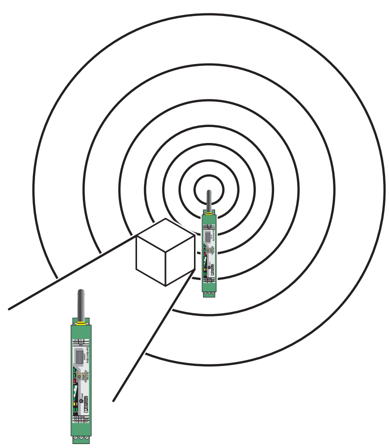


Figure 11-9 Radio dead spot

Weather influences

Snow, rain or hail have no effect on the wireless signal in the 900 MHz range.

A strong wind does not influence the wireless signal, however, it places high requirements on the secure fixing of the antenna. In particular when using panel antennas with a small apex angle, you should ensure that the antenna cannot be shifted by the wind. If the antenna is moved by just 1 cm from its original position, this can result in a partial loss of the wireless signal, especially when it has a long transmission path.

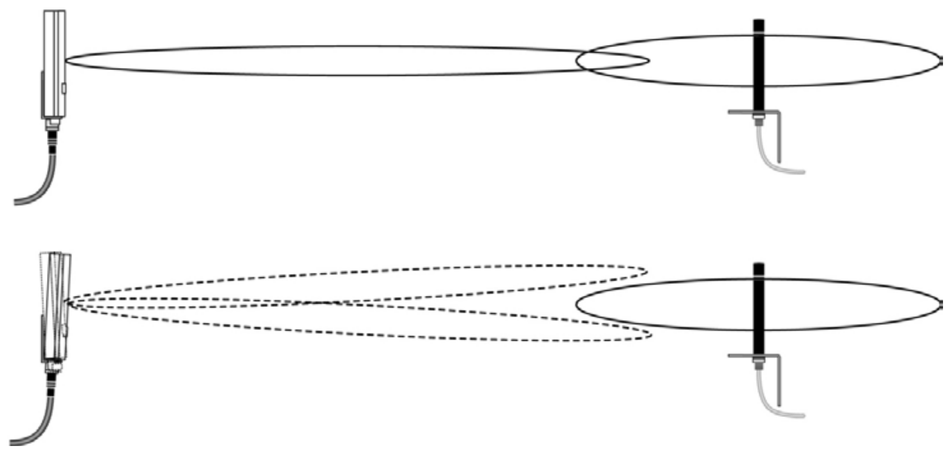


Figure 11-10 Wireless path with strong wind

11.7 Fresnel zone

A certain area between the transmitting and receiving antennas on the wireless path is referred to as the Fresnel zone. There should be a line of sight, especially in the event of longer distances, between the antennas. To adhere to the Fresnel zone, you might be required to install the antennas at a height of a few meters. This area should also be free from any other obstacles.

The ideal wireless path with a direct line of sight between transmitter and receiver is not always possible. In applications, obstacles often have to be taken into consideration, which affect the wireless channel. The wireless path may also work if obstacles (house, tree, etc.) are within the Fresnel zone. The decisive factor is the number of obstacles and the area they occupy in the Fresnel zone. In this case, you should carry out test measurements.

Inside buildings, e.g., in conventional automation environments, there is a predominance of reflections. They contribute to a good wireless connection even if the Fresnel zone is not free from obstacles.

The following figure shows the Fresnel zone between two antennas. The required mounting height for the antennas depends on the radius of the Fresnel zone.

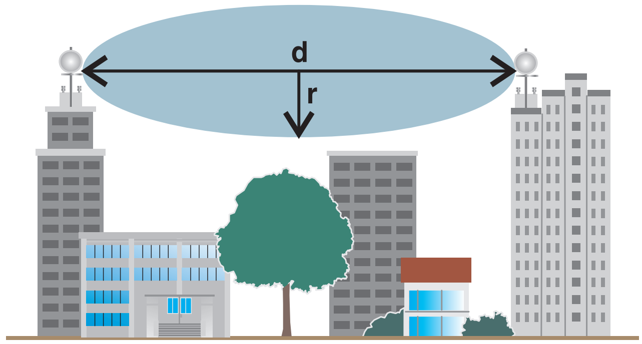


Figure 11-11 Fresnel zone

Table 11-2 Radius of the Fresnel zone depending on the distance

Wireless path distance (d)	Radius of the Fresnel zone (r) at 900 MHz
200 m	4 m
500 m	6.4 m
1000 m	9 m
2000 m	12.8 m
4000 m	18.1 m

General formula for calculating the diameter of the Fresnel zone:

$$r = 0.5 \times \sqrt{\lambda \times d}$$

r = radius of the Fresnel zone
λ = wavelength (0.328 m at 900 MHz)
d = distance between the antennas in km

Radius of the Fresnel zone with d = 3000 m:

$$r = 0.5 \times \sqrt{0.328 \times 3000}$$

r = 15.68 m

Result: The radius of the Fresnel zone is 15.68 m at a wavelength of 0.328 m (900 MHz) and a distance of 3000 m between the antennas.

11.8 Equivalent isotropically radiated power (EIRP)

The equivalent isotropically radiated power is a gauge of the radiation power of an antenna. The EIRP value is the sum of the transmission power in dBm and the antenna gain in dBi.

Example:

– Transmission power = 30 dBm
– Antenna gain = 2 dBi
– Attenuation through a 3 m long cable = 2.85 dB

– EIRP = 30 + 2 - 2.85 dBm = 29.15 dBm

11.9 System calculation in free space

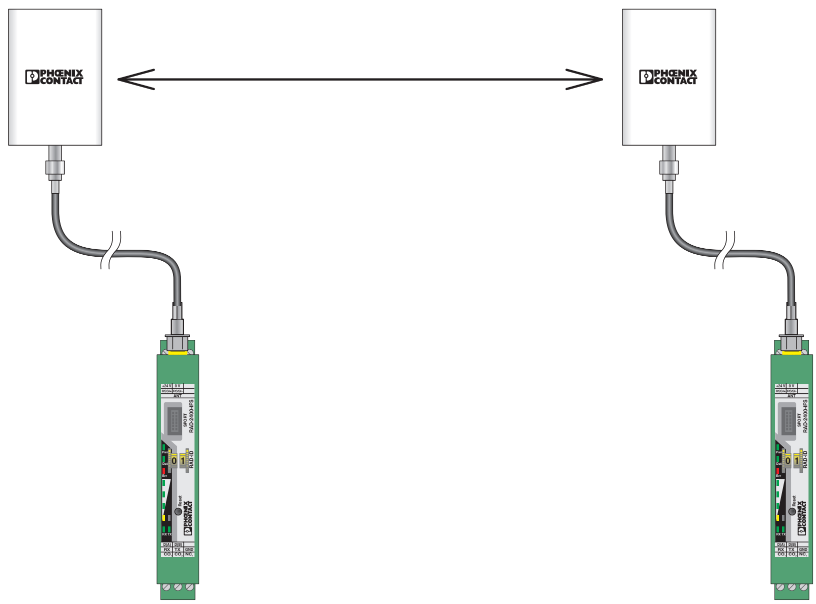


Figure 11-12 Free space path loss

Antenna gain per antenna: 0 dBi

Transmission power per wireless module: 30 dBm

Cable attenuation per cable (3 m): 2.85 dB

Free space path loss 400 m: 83.5 dB

Example calculation with optimal free space

- Wireless technology: Trusted Wireless
- Wireless path length: 400 m
- Device transmission power + antenna gain - cable attenuation (EIRP): ≤30 dBm
  (30 dBm must not be exceeded for legal reasons, adapt the cable, adapter or transmission power, if required)

EIRP [dBm] =
transmitter power [dBm]
+ gain of sending antennas [dBi]
- losses of the transmitter cable [dB]

Incoming power for the receiver [dBm] =
transmitter power [dBm]
- losses of the transmitter cable [dB]
+ gain of the sending antenna [dBi]
- free space path loss [dB]
+ gain of the receiving antenna [dBi]
- attenuation of the antenna cable at the receiver [dBm]

System reserve =
receiver sensitivity [dBm]
- incoming power for the receiver [dBm]
(recommended system reserve >10 dB)

EIRP = 29.15 dBm

Free space path loss [dB] =
32.4 + 20 log(f[MHz]) + 20 log(R[km]) = 32.4 + 20 log(900) + 20 log(0.4) = 83.5 dB

Incoming power for the receiver = -55.2 dBm

Receiver sensitivity = -105 dB (with a data rate of 125 kbps)

System reserve = 105 dB - 55.2 dB = 49.8 dB

Conclusion: The losses of 55.2 dB are significantly lower than the receiver sensitivity of -105 dB. The desired wireless connection is therefore possible in mathematical terms.

12 Detecting and removing errors

If your wireless system does not function properly, proceed as follows:

- First, ensure that you have a good wireless signal (2 green bar graph LEDs or RSSI voltage ≥1.5 V).
- Check the status of the individual stations:
  - If the PSI-CONF software is installed, check the device status of all network devices via online diagnostics.
  - If the PSI-CONF software has **not** been installed, check the bar graph LEDs on the front of each device.
- Find the error using the tables from page 140 onwards.

Avoid contact between the antennas of two wireless module, otherwise the receiver might become overloaded.

Ground loops are caused by the grounding of the antenna via the antenna fixing unit, grounding the power supply or serial interface. To avoid ground loops, connect these components to a single ground point.

Strength of the receive signal

You can determine the strength of the receive signal by means of the RSSI voltage. The signal strength is displayed on the LED bar graph on the wireless module.

- In a point-to-point connection, the LED bar graph is active on the master and on the repeater/slave.
- In a wireless network with more than one repeater/slave, only the yellow LED on the master is permanently on. The signal strength is displayed on the repeaters/slaves. The displayed signal strength is always related to the next wireless module in direction of the master (parents).

The RSSI indicator is a voltage output in the range between 0 V DC ... 3 V DC. The higher the voltage, the better the wireless connection. The measured voltage is directly related to the receive signal in -dB. However, please observe the small voltage fluctuation due to multipath propagation.

The recommended minimum signal strength is 1.5 V DC. This results in a power reserve of approximately 10 dB which ensures communication even in the event of unfavorable transmission conditions.

You can measure the RSSI voltage at the RSSI test socket or read it using the PSI-CONF software. When connecting the master wireless module to a PC, you can read the RSSI voltages in the entire wireless network. At a slave or repeater, it is only possible to read the RSSI voltage of the specific wireless module connected.

Table 12-1 RSSI voltage

		16k	125k	250k	500k	RSSI voltage
LED 3		-75 dBm	-70 dBm	-65 dBm	-60 dBm	2.5 V
LED 2		-85 dBm	-80 dBm	-75 dBm	-70 dBm	2.0 V
LED 1		-95 dBm	-90 dBm	-85 dBm	-80 dBm	1.5 V
LINK LED		LINK	LINK	LINK	LINK	~1.0 V

Table 12-2 Detecting and removing errors: wireless module

LED, wireless module	Current state and possible cause	Solution
-	Wireless module cannot be configured using the PSI-CONF software	• Make sure that the wireless module is supplied with power. • Make sure that you are using the correct cable: – RAD-CABLE-USB (Order No. 2903447), power supply via the USB port on the PC – IFS-USB-DATACABLE (Order No. 2320500), external power supply • Install the USB driver. The driver is installed automatically during PSI-CONF software installation (see page 38).
PWR off	No power supply, mains probably switched off.	• Switch the mains on, restore the power supply.
DAT off	No communication between wireless module and I/O extension module. Wireless module possibly in “Serial data” operating mode.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector and whether it is connected to the wireless module. • Check the operating mode of the wireless module using the PSI-CONF software. The wireless module must either be in “I/O data” or “PLC/Modbus RTU” mode (see page 38). • Reset the wireless module to the default settings (I/O data mode), if required. Disconnect the device from the supply voltage, hold down the SET button and switch the supply voltage on again (see page 31).
ERR on	Local bus error The input or output module is disconnected from the DIN rail connector and the bus.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Press the SET button on the front of the wireless module or carry out a power up. The data of the I/O extension modules are read in again.
ERR + DAT flashing	Writing to the memory stick has not been possible	• Repeat the process in order to correctly write to the memory stick.

LED, wireless module	Current state and possible cause	Solution
ERR flashing fast (2.8 Hz), bar graph does not light up	No wireless connection, even though the wireless modules are **not** far away from each other	• Make sure that, in a network, only one wireless module is configured as the master (RAD ID = 01) and all other wireless modules are slaves or repeaters. Reconfigure the wireless network, if necessary. • Check whether the set RAD ID is a permitted address. • Make sure that each RAD ID (yellow thumbwheel) only occurs once in the network. • There could be an overload problem: In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 20 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices/antennas or reduce transmission power using the PSI-CONF software (from page 38 onwards). • Using the PSI-CONF software, check whether the network parameters have the same settings on all wireless modules (operating mode, network ID, RF band, data rate of the wireless interface, encryption, network type, from page 38 onwards). • Reset the wireless module to the default settings (I/O data mode), if required. Disconnect the device from the supply voltage, hold down the SET button and switch the supply voltage on again (see page 31).
	No wireless connection, the wireless modules are far away from each other	• Check whether the antennas are connected and aligned properly. • Make sure that the antenna connections are tight and free from corrosion. • Install the antenna at a higher point. Adhere to the Fresnel zone. • Use a different antenna with higher antenna gain or use shorter cables with lower signal attenuation. • Check whether there is another transmitting antenna in close proximity. Position the antenna further away from all other antennas (at least 1 m in the horizontal direction or 0.6 m in the vertical direction). • Make sure that the power supply is sufficient. • Make sure that there is no connection between the core and the shield of the cable in the connected antenna system.

LED, wireless module	Current state and possible cause	Solution
LED bar graph, yellow LED is on only	Connection with low receive signal	• Check whether the antennas are connected and aligned properly. • Make sure that the antenna connections are tight and free from corrosion. • Install the antenna at a higher point. Observe the Fresnel zone. • Use a different antenna with higher antenna gain or use shorter cables with lower signal attenuation. • Check whether there is another transmitting antenna in close proximity. Position the antenna further away from all other antennas (at least 1 m in the horizontal direction or 0.6 m in the vertical direction). • Make sure that the power supply is sufficient. • Make sure that there is no connection between the core and the shield of the cable in the connected antenna system.
	Several repeaters/slaves at the wireless master	• No action required, normal display for a wireless network with more than one repeater/slave. The signal strength is indicated on the repeaters/slaves and is always related to the next wireless module in the direction of the master (parents).
In I/O data mode		
ERR flashing slowly (1.4 Hz)	Double assignment of IO-MAP address, two input modules have the same I/O-MAP address in a network	• The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O-MAP addresses.
	Missing input module Example: An output module does not have the corresponding input module with the same I/O-MAP address.	• Check whether an input module with the same I/O-MAP address has been assigned to each output module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O-MAP address as the assigned output module at the other wireless station.
	Missing output module Example: An input module does not have the corresponding output module with the same I/O-MAP address.	• Check whether an output module with the same I/O-MAP address has been assigned to each input module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The output module must be provided with the same I/O-MAP address as the assigned input module at the other wireless station.
	RAD ID changed Example: The yellow thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the RAD ID setting on the yellow thumbwheel of the wireless module. • If necessary, set the correct RAD ID and press the SET button.

LED, wireless module	Current state and possible cause	Solution
In PLC/Modbus RTU mode		
ERR flashing slowly (1.4 Hz)	Double assignment of I/O-MAP address, two input modules have the same I/O-MAP address in a network	• The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O-MAP addresses.
	RAD ID changed Example: The yellow thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the RAD ID setting on the yellow thumbwheel of the wireless module. • If necessary, set the correct RAD ID and press the SET button.
	No Modbus communication (only if watchdog is activated) Example: The communication line between the Modbus/RTU controller and the master wireless module is broken.	• Check the communication line between the Modbus/RTU controller and the master wireless module with RAD ID 01. • Check the wiring of the RS-232/485 connections on the wireless modules. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the wireless modules and serial termination devices. • Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Check whether the wireless module is in PLC/Modbus RTU mode using the PSI-CONF software (see page 38). • Press the SET button on the wireless module or carry out a power up in order to read in the station structure.
In “Serial data” or “PLC/Modbus RTU” mode		
RX, TX off	Wireless connection present, but application does not transmit any data	• Check the wiring of the RS-232/485 connections on the wireless modules. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the wireless modules and serial termination devices (from page 38 onwards).

Table 12-3 Detecting and removing errors: I/O extension module

LED, I/O module	Current state and possible cause	Solution
PWR off	No power supply. Mains probably switched off.	• Switch the mains on, restore the power supply.
DAT off	No communication between wireless module and I/O extension module. Wireless module possibly in “Serial data” operating mode.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector and whether it is connected to the wireless module. • Check the operating mode of the wireless module using the PSI-CONF software. The wireless module must either be in “I/O data” or “PLC/Modbus RTU” mode (see page 38). • Reset the wireless module to the default settings (I/O data mode, see page 31), if required.
ERR on	Critical internal error Example: Technical defect	• Please contact Phoenix Contact technical support.
ERR flashing slowly (1.4 Hz)	I/O-MAP address changed Example: The white thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the IO-MAP address setting on the white thumbwheel of the I/O extension module. • If necessary, set the correct I/O-MAP address and press the SET button on the wireless module.
In I/O data mode		
ERR flashing fast (2.8 Hz)	Missing input module Example: An output module does not have the corresponding input module with the same I/O-MAP address.	• Check whether an input module with the same I/O-MAP address has been assigned to each output module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O-MAP address as the assigned output module at the other wireless station.
	No bus communication, no wireless connection present	• See measures for the wireless module, page 141
In PLC/Modbus RTU mode		
ERR flashing fast (2.8 Hz)	No Modbus communication (safe state of outputs, depending on DIP switch setting)	• Check the communication line between the Modbus/RTU controller and the master wireless module with RAD ID 01. • Check the wiring of the RS-232/485 connections on the master and the PLC. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the master and the PLC (from page 38 onwards). • Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Check whether the wireless module is in PLC/Modbus RTU mode using the PSI-CONF software (see page 38). • Press the SET button on the wireless module or carry out a power up in order to read in the station structure.
	No bus communication, no wireless connection present	• See measures for the wireless module, page 141

12.1 Loopback test during serial data transmission

With an RS-232 interface, you can use the loopback test to check the data path from the master to the slave and back again. To this end, you need to short-circuit two terminal points of the RS-232 interface on the slave wireless module. It is then possible to transmit characters to the master wireless module using a terminal program (e.g., HyperTerminal). The characters are echoed back to the terminal program.

> Note for Windows 7 users:
>
> HyperTerminal is no longer available in Windows 7. Instead you can use any other terminal program.

To carry out a loopback test, proceed as follows:

- Close all PC programs on your PC, including the PSI-CONF software.
- Connect the PC to the master wireless module and start HyperTerminal via "Start, All Programs, Accessories, Communication, HyperTerminal". The COM port settings on the PC must correspond to the interface settings on the master wireless module.
- Connect the terminal points 5.1 and 5.2 of the RS-232 interface on the slave module you need to test.

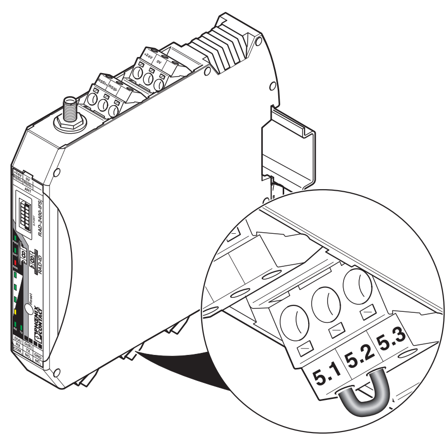


Figure 12-1 Loopback test for an RS-232 interface

- Connect both wireless modules to the power supply.
- Check the wireless connection via the LED bar graph.

- Enter several characters of your choice. HyperTerminal transmits these characters over the wireless path. On the slave side the characters are output (e.g., at terminal point 5.1, RX cable of the RS-232 interface) and immediately read again using the bridge (e.g., at terminal point 5.2, TX cable of the RS-232 interface). This returns the already transmitted characters and they appear twice on the HyperTerminal screen.
  – The screen remains blank if the check was not successful. Monitor the TX and RX LEDs on every wireless module. You can thereby determine the point up to which data has been transmitted.
  – In case the characters only appear once, check the HyperTerminal settings for hidden outgoing characters. The following options must be enabled under "File, Properties, Settings, ASCII Setup":
  "Echo typed characters locally" and
  "Append line feeds to incoming line ends"

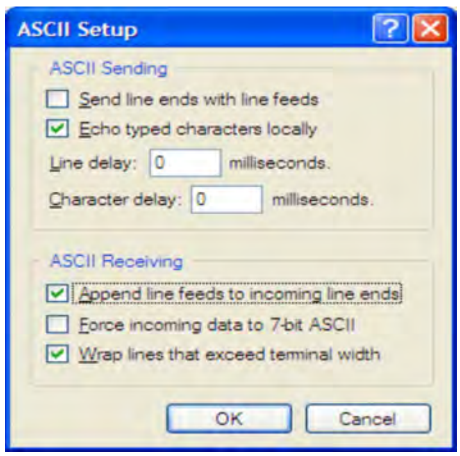


Figure 12-2 Settings in HyperTerminal

A Technical appendix

A 1 Configuring a PROFIBUS connection

In order to configure a point-to-point or star connection for PROFIBUS transmission, proceed as follows:

- Download the latest PSI-CONF software from the Internet at phoenixcontact.net/products.
- Install the software on your computer.

WARNING: Explosion hazard when used in potentially explosive areas
The USB cable must **not** be used in potentially explosive areas.

- Use the RAD-CABLE-USB cable (Order No. 2903447) to connect the wireless module to the PC.

Configuring the connection

- Start the PSI-CONF software.

Figure A-1 PSI-CONF software

- In the “Wireless” folder, select the device.

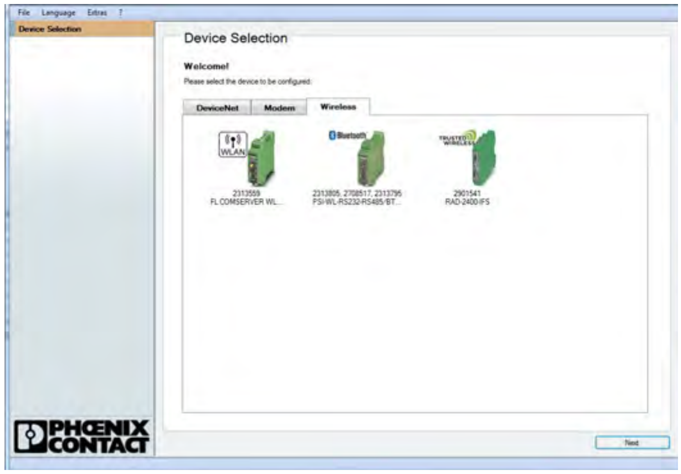


Figure A-2 PSI-CONF software: Device Selection

- Select “Create new network project”.

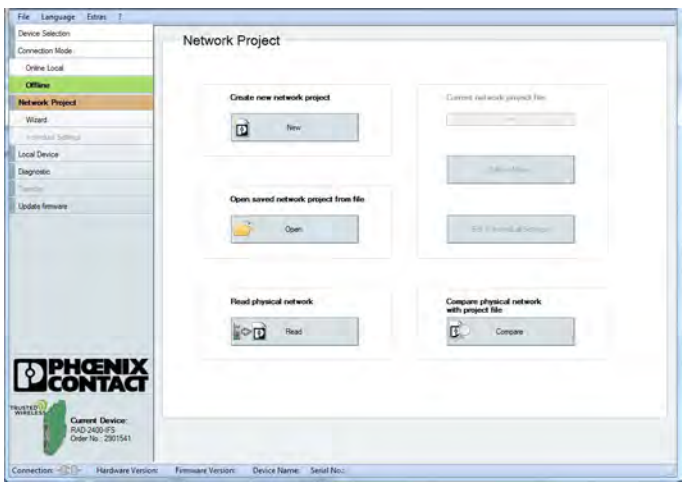


Figure A-3 PSI-CONF software: Network Project

- In step 1 of the wizard, select “Point to Point / Star” and confirm with “Next”.

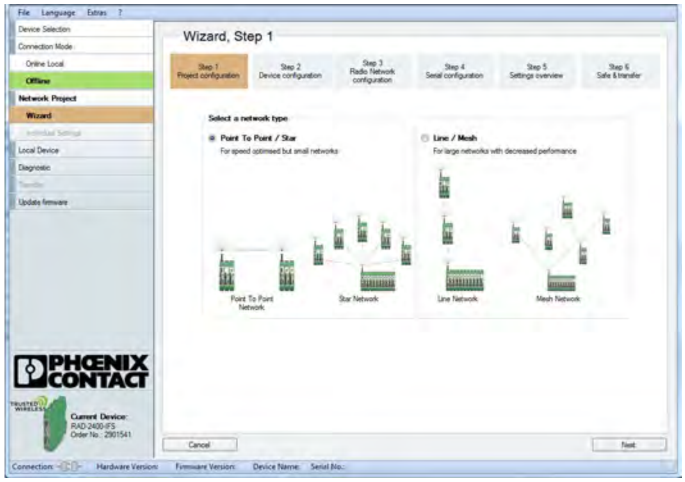


Figure A-4 PSI-CONF software: Wizard, Step 1

- Follow the software wizard. Specify the number of network devices. Confirm with “OK” and “Next”.

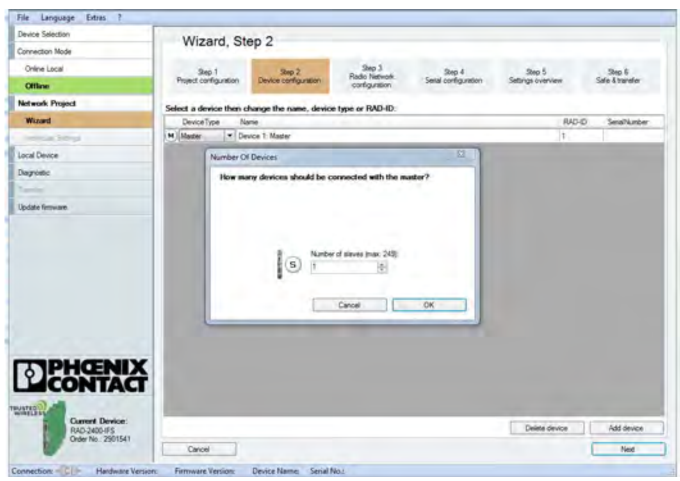


Figure A-5 PSI-CONF software: Wizard, Step 2

- In step 3, select the “Serial data” network application. Configure the network settings:
  - RF band
  - Network ID
  - Optional: showing/hiding WLAN channels
- Depending on the distance between the wireless modules, you can set the desired data rate under “Network speed/distance relation”.

You can achieve transmission within the kilometer range using the wireless module if the following conditions are fulfilled:

- Suitable gain antennas are used
- Line of sight
- Adherence to the Fresnel zone

- Then confirm with “Next”.

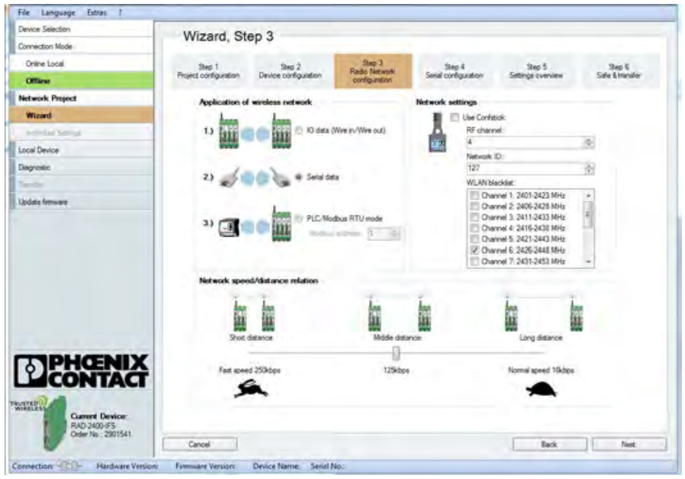


Figure A-6 PSI-CONF software: Wizard, Step 3

- In step 4, select the PROFIBUS connection profile and set the desired data rate. Depending on the distance to be covered, reduce the serial data rate (wireless interface 125 kbps or 250 kbps), if required. Confirm with “Next”.

Owing to the increased delay time, PROFIBUS transmission with 16 kbps is **not** possible.

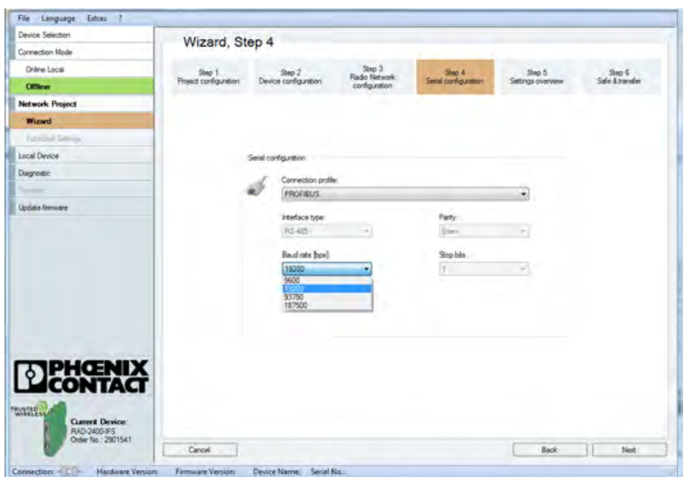


Figure A-7 PSI-CONF software: Wizard, Step 4

- In step 5, you will see an overview of the settings that have already been made. Check these settings and confirm with “Next”.

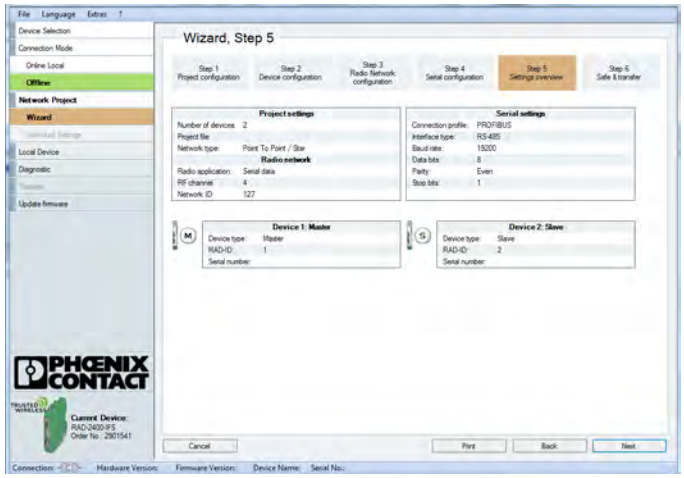


Figure A-8 PSI-CONF software: Wizard, Step 5

- Save the project in step 6.

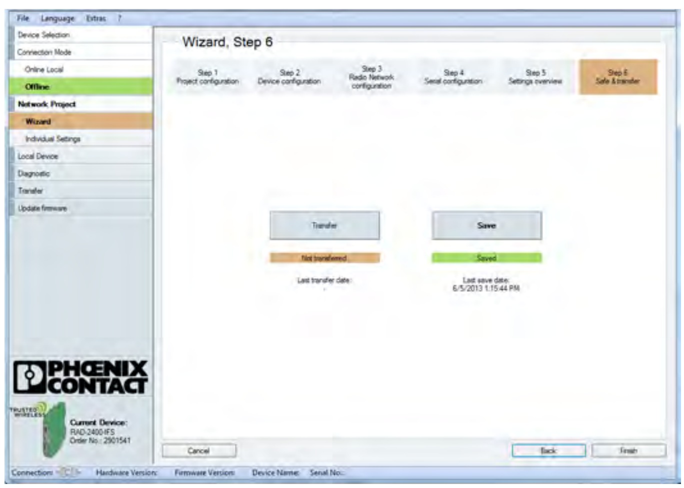


Figure A-9 PSI-CONF software: Wizard, Step 6

- Open “Individual Settings” and set “Transmissions” to 1. Save the settings again and click “Transfer” to transfer them to the devices.

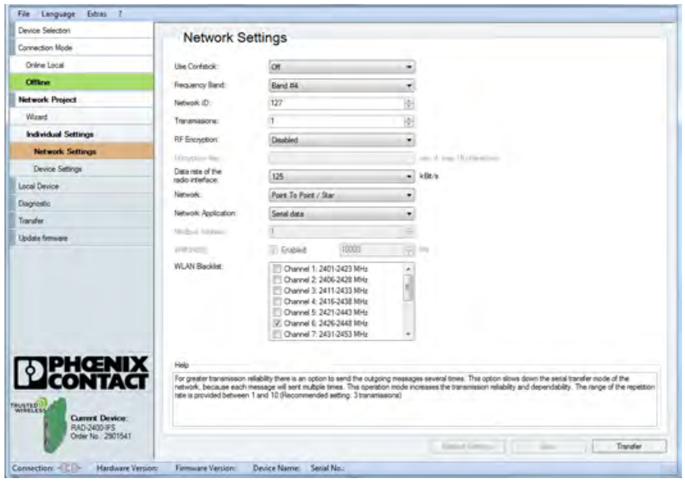


Figure A-10 PSI-CONF software: Network Settings

Connecting the PROFIBUS cable

- Connect the PROFIBUS cable to both wireless modules:
  - Negative data wire (green) to terminal D(A) 4.1
  - Positive data wire (red) to wire D(B) 4.2
- Activate bus termination if the wireless module is located at the start or the end of the electrical PROFIBUS segment. To do so, set the DIP switches 1 and 2 to ON. The DIP switches are located on the side of the wireless module.

Configuring the PROFIBUS master

- Adjust timing in the PROFIBUS master to the signal runtime over the wireless path.

This setting is shown here using the SIMATIC Manager, Version 5.x as an example:

The wireless modules do not modify the PROFIBUS telegram (transparent transmission, “Tunneling”). They only modify the PROFIBUS cycle time. In the case of an optimal wireless connection, the wireless modules will cause a delay time of approximately 50 ms, unidirectionally approximately 25 ms.

If the wireless component is connected in series with other components, then the delay time of each component needs to be added together. Remember to take into account long cables, repeaters, fiber optics, other wireless components, etc.

The additional delay time may increase in the event of a poor wireless connection. Alternatively, the connection may be terminated completely. In the case of a bad connection, the wireless module will not discard PROFIBUS telegrams but try to repeatedly transmit them.

- For the wireless connection, consider the following PROFIBUS situations:
  - **In the PROFIBUS master - minimum delay time of 50 ms**
    Tslot_Init parameter (maximum wait time for receipt)
  - **In the ROFIBUS master - short interruption of the wireless connection**
    Retry-Limit parameter (maximum number of connection retries)
  - **In the PROFIBUS slave - permanent interruption of the wireless connection**
    Watchdog time parameter
  - Telegram size: 40 bytes user data, maximum

- You have two options for setting the Tslot_Init parameter (maximum wait time for receipt):
  - **Automatically** - Enter the number of repeaters and the cable length under “Options, Cables”.
  - **Manually** - Directly enter the bus parameters under “User-defined, Bus Parameters”. In this case, deactivate the automatic calculation, otherwise the sum of the automatic and manual entry will be used.

We recommend that you use the manual entry:

- Entry: Tslot_Init > 13000 t_bit
- Entry: Retry-Limit > 3
- Recalculate
- Entry: Watchdog time, depending on the application

In certain circumstances, it may be required that the Tslot_Init value is greater than 13000 t_bit. For example, this may occur, if there is a poor wireless connection or the components are connected in series. The value of 50 ms will increase by the factor x.

The Tslot_Init parameter is expressed in t_bit. The maximum value for a Siemens S7 PLC is 16383 t_bit (S5: 9999 t_bit). The maximum wait time for receipt is therefore 93.75 kbps = 174 ms. In this case, the value 13000 t_bit is the minimum delay time of the wireless module + reserve.

- Start the SIMATIC Manager and open you user project. Select “Extras, Configure network” from the pull-down menu.

Figure A-11 SIMATIC Manager

- In the “NetPro” window, right-click the PROFIBUS line. In the context menu, open “Object Properties”.

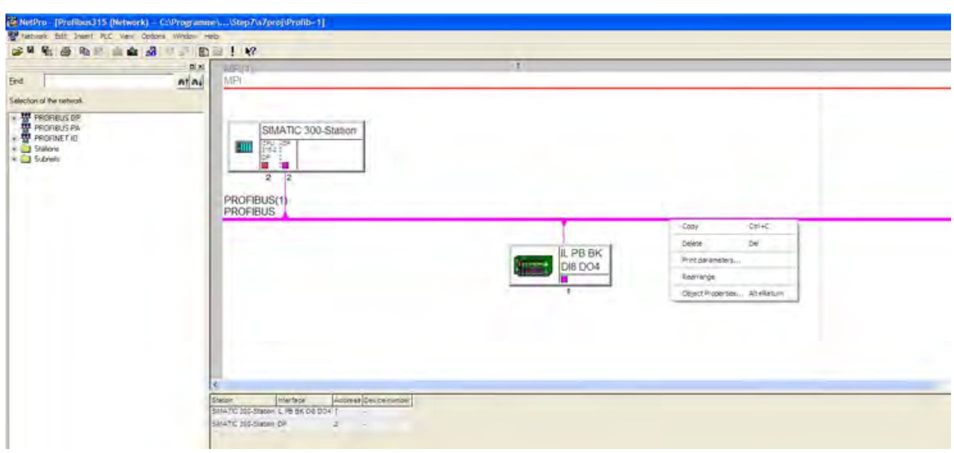


Figure A-12 “NetPro” window

- In the “Network Settings” tab, select the transmission speed of 93.75 kbps.
- Click “Options”.

Figure A-13 “Network Settings” tab, Transmission Rate

- In the “Cables” tab, deactivate the “Take into account the following cable configuration” option. Confirm with “OK”.

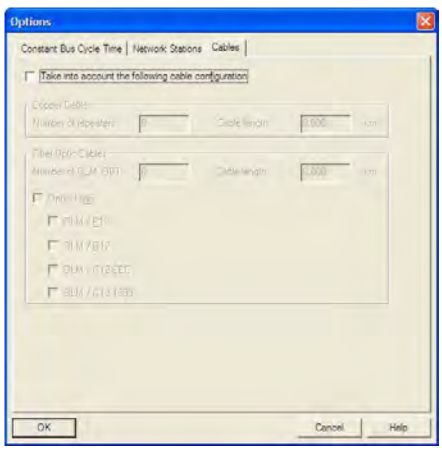


Figure A-14 “Cables” tab

- In the “Network Settings” tab, select the “User-Defined” profile and the “Bus Parameters” option.

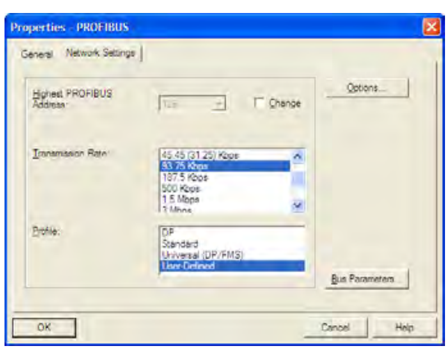


Figure A-15 “Network Settings” tab, Profile

- In the “Bus Parameters” tab, the most recently valid bus parameters are shown. Enter the following values:

> The value for the Tslot time and the telegram runtime of PROFIBUS depend on your application. Start with 13000 t_bit in order to achieve the smallest possible telegram runtime. Increase the value if bus errors occur.

Tslot_Init	13000 t_bit ... 16383 t_bit
Max. Tsdr	60
Min. Tsdr	11
Tset	1
Tqui	0
Gap factor	10
Retry_Limit	5

- Confirm the entry with “Recalculate”.

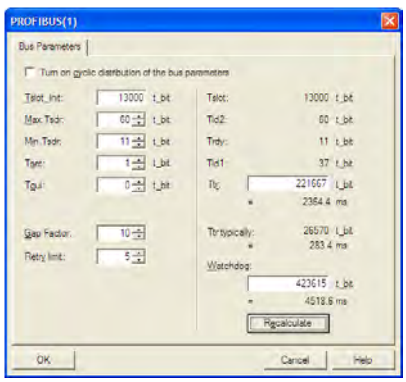


Figure A-16 “Bus Parameters” tab

- Recalculating the bus parameters also modifies the watchdog value. Enter 93750 t_bit here to achieve a watchdog time of 1 second for the PROFIBUS slave. Confirm with “OK”.

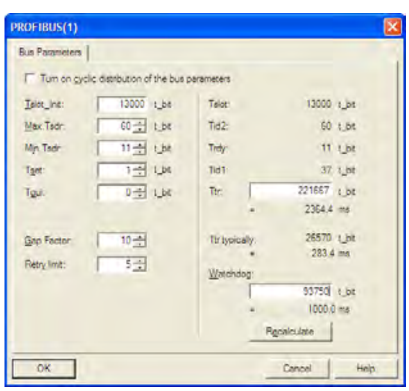


Figure A-17 “Bus Parameters” tab, Watchdog

- Go back to the “NetPro” view. Save and compile the changes.
- Transfer all settings to the PROFIBUS master.

- Test the accessibility of the PROFIBUS devices via the wireless path.

PROFIBUS controller in DP slave mode

You can change the operating mode of the PROFIBUS controller under “Properties - DP”. The DP controller can be operated as a master or slave.

To ensure error-free operation, the “Test, commissioning, routing” box must **not** be enabled. If this option is activated, the interface becomes an active PROFIBUS device and takes part in the token rotation of PROFIBUS.

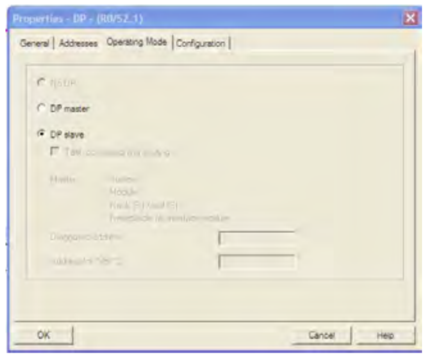


Figure A-18 ”Properties - DP” tab

B Appendixes

B 1 List of figures

Section 6

Section 7

Section 8

Section 10

Section 11

Section 12

Appendix A

B 2 List of tables

Section 3

Section 4

Section 5

Section 7

Section 8

Section 9

Section 10

Section 11

Section 12

B 3 Index

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W

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FAX (831)462-8246

"Making Solar Simple"

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MAPPS SPECIFICATIONS

Photovoltaic Modules
- High Efficiency Crystalline Silicon
- Meet JPL Block V Durability Criteria
- Tempered Glass and Aluminum Frame
- Module Warranty up to 25 Years

Gel Cell Sealed Batteries
- Sealed Maintenance-Free
- Excellent Deep-Cycling Performance
- Immobilized Electrolyte, Non-Spillable
- Transports Easily and Safely

Charge/Load System Controller
- Field Proven High Efficiency Design
- Temperature Compensated Charging
- Low Voltage Load Disconnect
- Most Models UL Listed and FM Approved

Balance of System Components
- Weatherproof Battery/Controller Enclosure
- Heavy Duty Aluminum Mounting Structures
- Color-Coded, Pre-Cut Wiring Harness
- Easy-to-Follow Manual/System Schematics

Optional Equipment Specifications

Lighting Control
- Ten field adjustable lighting control options
- Manı
- Detects day and night using the PV array

DC/AC Inverter for 120 VAC Systems
- Pure Sine Wave 120 VAC Power
- Low Battery Cutout Protection
- Overload & overtemp protection

Optional Accessories

Frangible Couplings
- Designed for Aviation and Roadside Apps
- Omni-directional breakaway support system

Aluminum shelf and backpanel
- DIN RAIL for customer load (s)
- Polyphaser surge protection for radios

DC to DC Voltage Converters
- Prewired on backpanel
- 12-24, 24-12, 24-24, 48-24, 12-48, 48-12 and more available

MAPPS Remote Photovoltaic Power System Datasheet

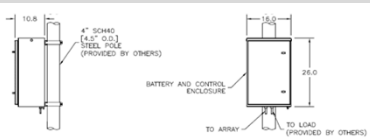
Model Number: MAPPS 190-108-24

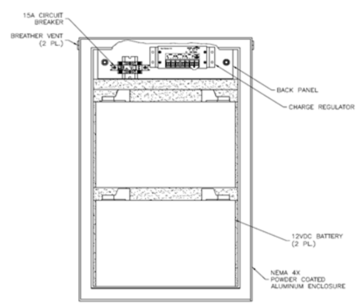
MAPPS Solar System Specifications	
Solar Array Wattage, Standard Test Conditions, STC	190 W
Nominal System Voltage	24 VDC
Battery System Storage, 100 hour rate	108 Amp-Hrs
Battery Type	Sealed Lead Acid Gel
Solar Module Certifications	ETL Listed to UL 1703, Class I Division 2, Group A, B, C, D
Battery Enclosure Rating	NEMA 4
MAPPS System Weight	175lbs (79.4kg)
MAPPS Upgrades	
Dusk/dawn Light Controller	Not Included
Frangible Coupling	Not Included
Radio Shelf	Not Included

MAPPS System Electrical Specifications	
Solar Array Max Power Current, Imp	5 A
Solar Array Short Circuit Current, Isc	5.5 A
Solar Array Vmp	38.0 VDC
Solar Array Voc	45.3 VDC
Solar Temperature Coefficient (Voc/°C)	-0.360%
Solar Charge Controller Amp Rating	10.0 A
Solar Charge Controller Voltage	24 VDC
Optional Dc to AC Sine Wave Inverter Wattage	N/A
Optional Dc to AC Sine Wave Inverter Nom. DC Voltage	N/A

MAPPS Solar Array Mechanical Specifications	
Solar Array Total Area	13.56 sq.ft (1.26sq.m)
Solar Array & Mounting Structure Total Weight	175lbs. (79.38kg.)
Solar Mounting Structure Mounting Method	Side-of-Pole
Solar Mounting Structure Wind Speed Rating	90 MPH
Solar Mounting Structure Material	Milled Aluminum

MAPPS Battery and Equipment Enclosure	
Mounting Method	Standard Pole Mount
Material	Anodized Aluminum
Enlosure Finish	Brushed Aluminum
Dimensions (LxWxH)	26.2 in. x 16.5 in. x 10.6 in. (2.44 m x 1.54 m x 0.99 m)
Weight (with Batteries)	140lbs. (63.51kg.)





MAPPS Optional Accessories	
Wind Speed Upgrade	No
Optional DC-DC Converter	No

Solar Electric Supply
104 Whispering Pines Dr #101
Scotts Valley Ca 05066
Tel: 831-462-8243 Fax: 831-462-8246

SOLAR ELECTRIC SUPPLY, INC.

MAPPS Solar Design v12.4

Project Name:	**Photovoltaic System Design Performance Analysis**	Model: MAP-190-108-24
Client Name:		**Date:** 12/19/2017
Company Name: CH2M		**Design By:** S. Williams
Insolation: Chicago/O'Hare, IL	*Weather Database*	**Site Location:** Chicago/O'Hare, IL
Latitude (Deg): 42.0		**System Type:** **Off-grid**

Nominal Battery Voltage: **24** **Average Volts/Cell:** 2.00 **Avg. Battery Voltage:** 24.0

Qty	Load Description	Current Amps	Voltage Vdc-Vac	Load Wattage	Use Hrs/day	Use Days/Wk	Conversion Eff. %	Total Ahr/day
1	RAD-900-IFS	0.3625	24	8.7	24	7	100.0%	8.7
1	RAD-AI4-IFS	0.13333	24	3.2	24	7	100.0%	3.2

Array Parameters

PV Module Name	SES 490			
			Load Ah/day	11.9
			Load Kwhr/day	0.286
Nominal Module Voltage	12	13.9% Eff.	Load Amps Max.	0.5
Module Peak Power Voltage	17.9		Module Amps Ipmax	5.03
# Modules in Series	2		Module Nom. Wattag	90
# Parallel Strings	1		Array Nom. Kilowatts	0.180
Array Derate %	15%		Derated Array Amps	4.3
Array Tilt (Deg):	45		Total # of Modules	2
Azimuth (Deg):	0			

MPPT ○ YES ● NO

Battery Parameters - Model: Deka 8G31 (12SC98) 108AH Gel

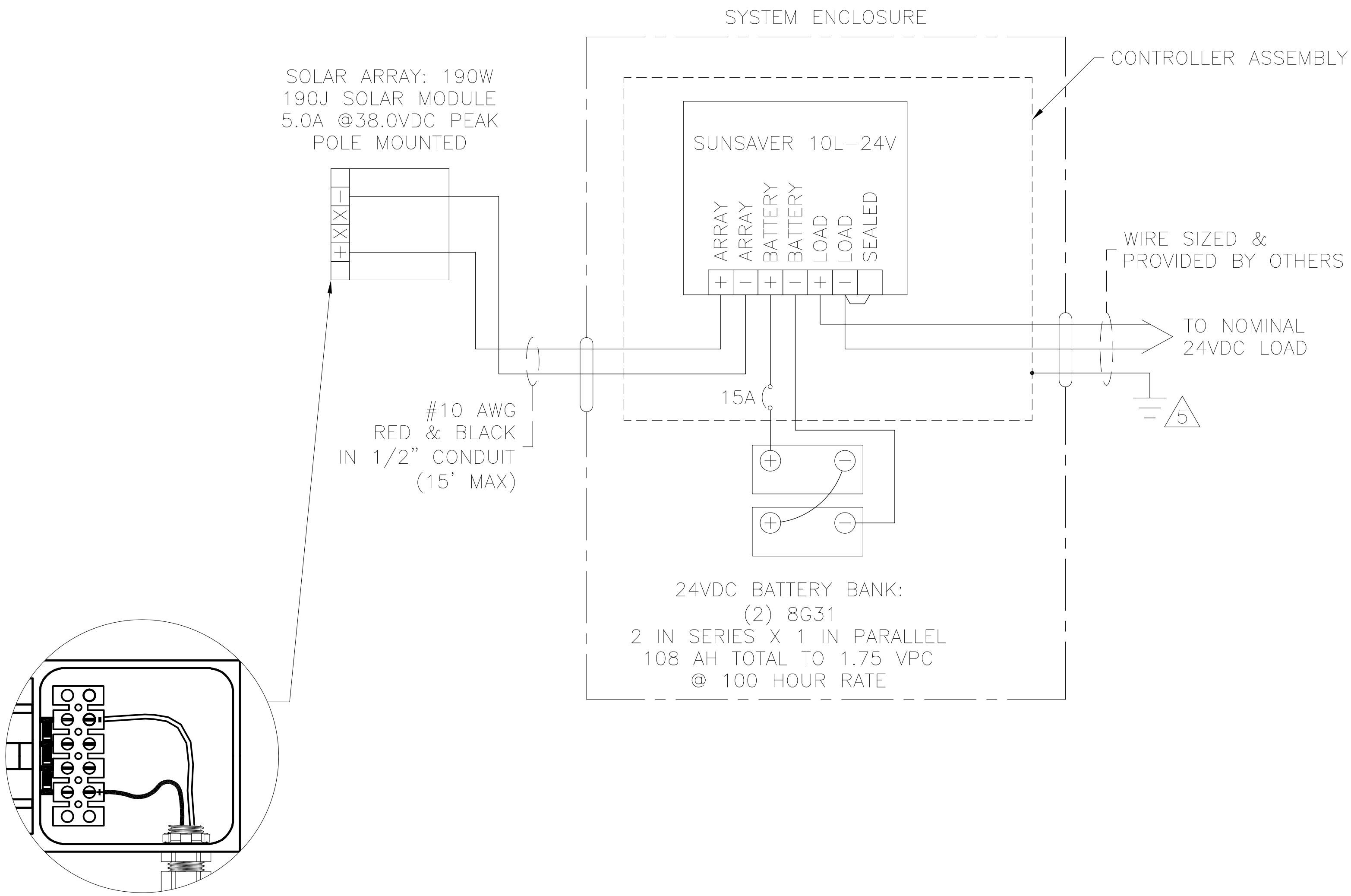
Capacity (AH @ 100 hr)	108		Autonomy (Days)	6.5
Nominal Battery Voltage	12		# of Batteries	2
# Batteries in Series	2		Total Rated Ahrs	108
# Batteries in Parallel	1		Total Derated Ahrs	97
Maximum Depth of Discharge	80%		Suggested Ahrs	110
Min. Avg. Ambient Temp.	-5.8	°C in January	Self Discharge % /Month	2%
Battery Capacity Derate%	10%	(Suggested Range: 15% - 20%)	Self Discharge Ahrs	1.9
	15%	(Default)		

Generator Parameters

		Minimum Gen Watts	0
Selected GenCharger Output (ADC):	0	Battery Charger Eff.	80%
Recommended charger output (ADC):	0	Altitude (Ft.)	1000
Charger min/max (ADC):	0	Gen Altitude Derate	0.0%
GEN START @ % SOC:	50%	Gen Annual Run Hrs	#DIV/0!
GEN STOP @ % SOC:	90%	Gen Annual Kwh	0

CALCULATED SYSTEM PERFORMANCE

MONTH	I Horz Kwh/D	I POA Kwh/Day	Load Ahr/day	PV Output Ahr/day	Gen Input Ahr/day	--- LOAD SUPPLIED BY --- % PV	% BAT	% GEN	Array/Load Ratio
JAN	1.81	3.36	12.0	14.4	0.0	100%	0%	0%	1.20
FEB	2.61	3.98	12.0	17.0	0.0	100%	0%	0%	1.42
MAR	3.48	4.15	12.0	17.7	0.0	100%	0%	0%	1.48
APR	4.59	4.66	12.0	19.9	0.0	100%	0%	0%	1.67
MAY	5.68	5.14	12.0	22.0	0.0	100%	0%	0%	1.84
JUN	6.27	5.37	12.0	23.0	0.0	100%	0%	0%	1.92
JUL	6.11	5.36	12.0	22.9	0.0	100%	0%	0%	1.92
AUG	5.36	5.20	12.0	22.2	0.0	100%	0%	0%	1.86
SEP	4.20	4.75	12.0	20.3	0.0	100%	0%	0%	1.70
OCT	2.99	4.16	12.0	17.8	0.0	100%	0%	0%	1.49
NOV	1.81	2.93	12.0	12.5	0.0	100%	0%	0%	1.05
DEC	1.46	2.60	12.0	11.1	0.0	93%	7%	0%	0.93
Annual	3.86	4.31	4379	6738	0	100%		0%	1.54



5. GROUND POINT ESTABLISHED BY CUSTOMER.
4. UNLESS OTHERWISE SPECIFIED, WIRING TO BE #14 RED POSITIVE (+), BLACK NEGATIVE (−), GREEN GROUND (⏚).
3. BATTERIES TO BE INSTALLED IN THE FIELD.
2. CONNECTIONS TO BATTERIES TO BE COMPLETED IN THE FIELD.
1. CONNECTIONS TO ARRAY TO BE COMPLETED IN THE FIELD.
NOTES:

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OWNERSHIP

WIRING DIAGRAM

MAPPS 190-108-24

UNITS

UNLESS OTHERWISE SPECIFIED:
PRIMARY UNITS ARE: INCHES
SECONDARY UNITS ARE: [mm]

REVISIONS

REV	REVISED BY	DATE

MISC

APPROVALS	NAME	DATE
DRAWN	E. RIVAS	16.JAN.17
APPROVED	–	–

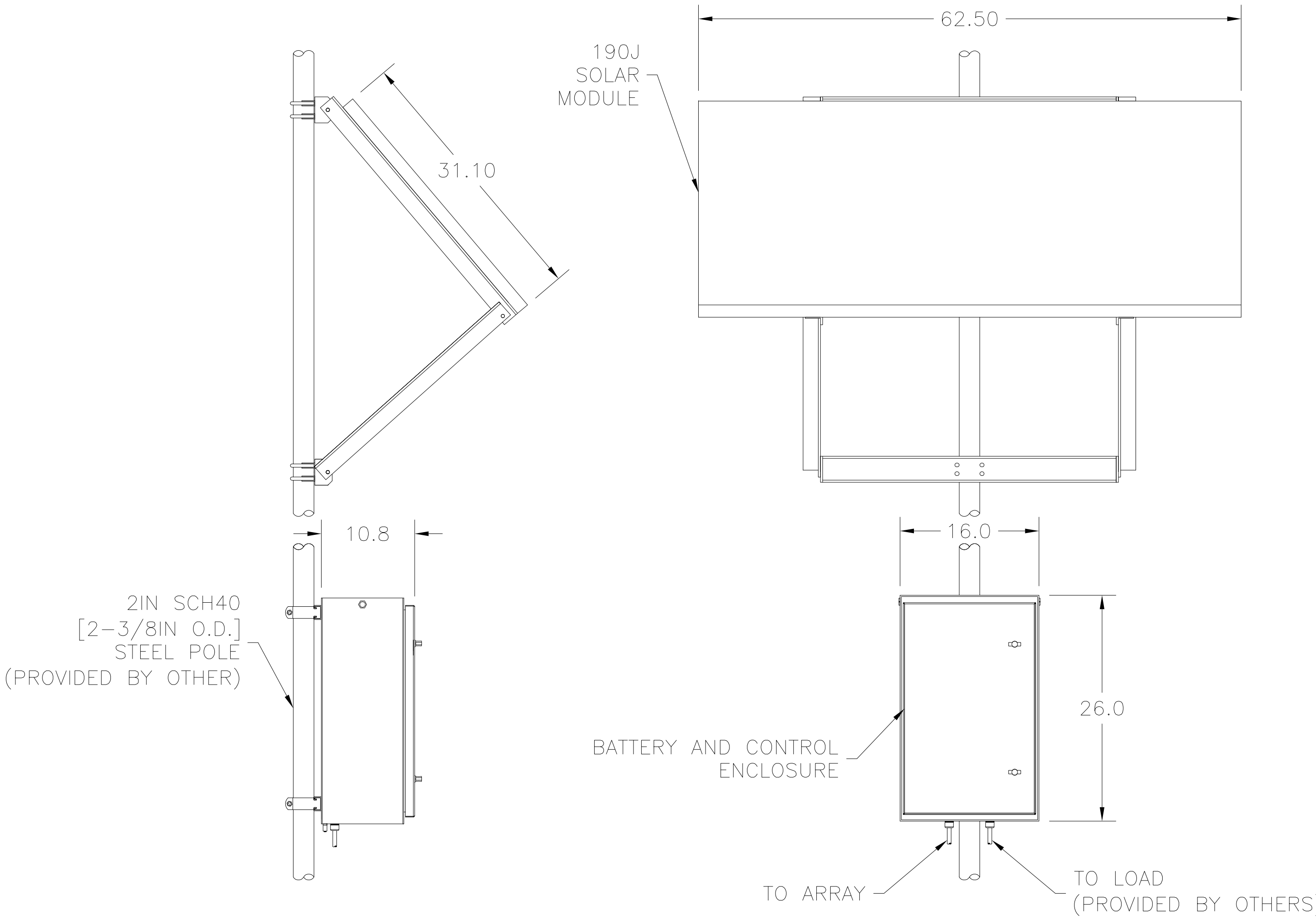
SCALE N/A

DRAWING NUMBER SD50-0167-SES

B.O.M. NUMBER SB50-0167-SES

SHEET 1 OF 3

SIZE A



SOLAR ELECTRIC SUPPLY, INC.

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OWNERSHIP

SITE LAYOUT

MAPPS 190-108-24

UNITS

UNLESS OTHERWISE SPECIFIED:
PRIMARY UNITS ARE: INCHES
SECONDARY UNITS ARE: [mm]

REVISIONS

REV	REVISED BY	DATE

MISC

APPROVALS	NAME	DATE
DRAWN	E. RIVAS	16.JAN.17
APPROVED	-	-

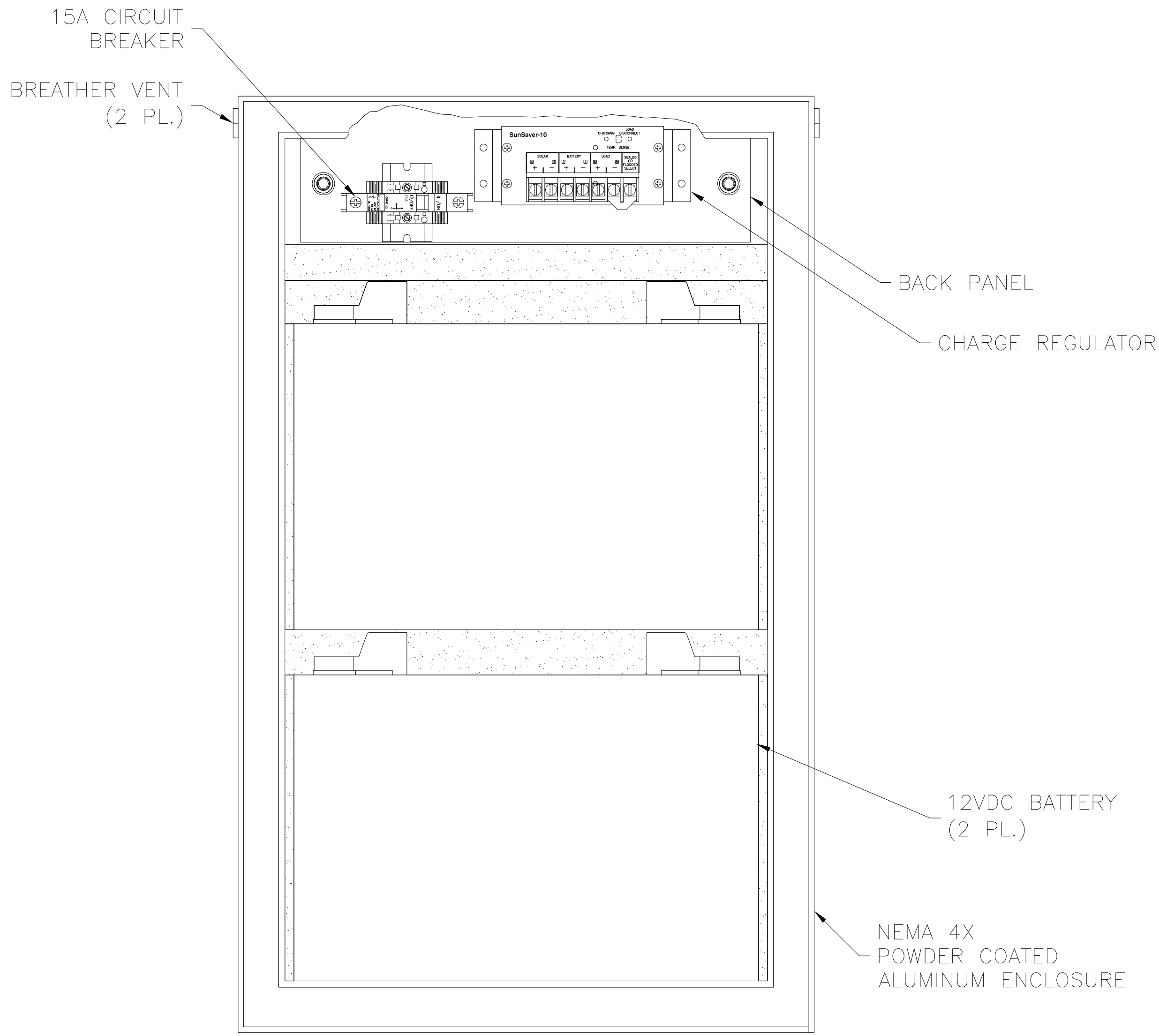
SCALE N/A

DRAWING NUMBER SD50-0167-SES

B.O.M. NUMBER SB50-0167-SES

SIZE A

PRINTED: 01.17.17 - 3:03 PM



2. BATTERIES TO HAVE EXPANDED POLYSTYRENE FOAM INSULATION ON ALL SIDES AND DOOR.
1. ENCLOSURE DOOR NOT SHOWN FOR CLARITY.
NOTES:

PRINTED: 01.17.17 – 3:03 PM

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OWNERSHIP

ENCLOSURE LAYOUT

MAPPS 190–108–24

UNITS

UNLESS OTHERWISE SPECIFIED:
PRIMARY UNITS ARE: INCHES
SECONDARY UNITS ARE: [mm]

REVISIONS

REV	REVISED BY	DATE

MISC

APPROVALS	NAME	DATE
DRAWN	E. RIVAS	16.JAN.17
APPROVED	–	–

SCALE N/A

DRAWING NUMBER SD50–0167–SES

B.O.M. NUMBER SB50–0167–SES

SHEET 3 OF 3

SIZE A

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Rugged Materials and Construction, Precision Engineering and Expert Support

1X-SPM: ROHN Tower:
- Fit ROHN25-45 Towers

1X-SPM: Pole Mounted:
- Fit 2" to 8" SCH 40 pipe

Photographs are intended to portray typical mount appearance, actual appearance my vary.

1. Solar Panel
2. Panel Kit Rail
3. Leg Kit
4. L-Bracket (Foot)
5. C-Channels (2X4X)
6. U-Bolts (not supplied)

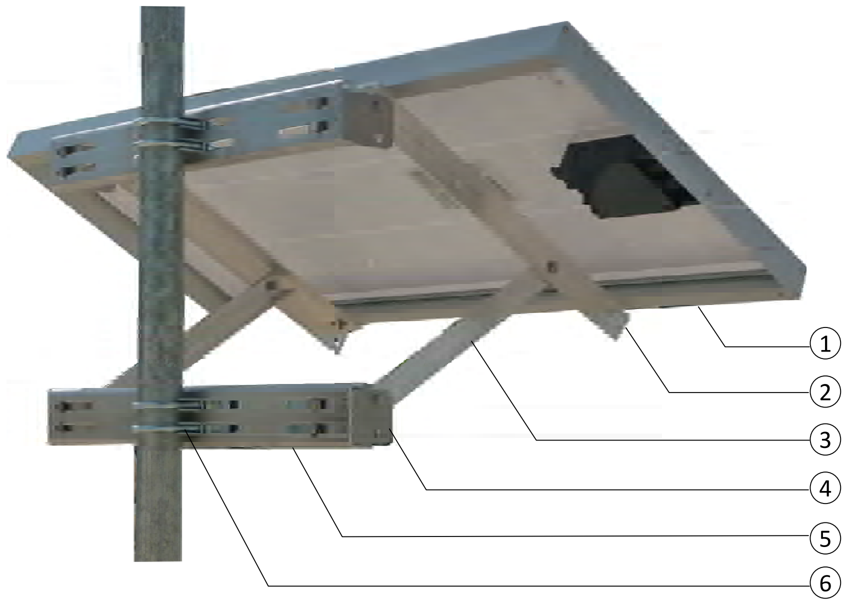
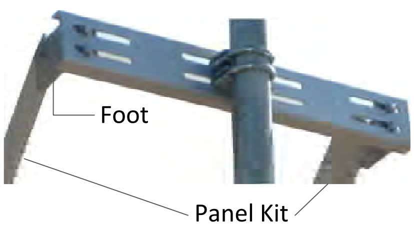


Figure 1. Mounting kit components

Upper Pole Attachment:



Lower Pole Attachment:

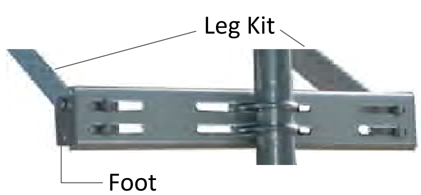


Figure 2. Attach the C-Channels to pole using U-Bolts.

Array Tilt Angle Selection: Table 1

SITE LATITUDE: (In Degrees)	FIXED TILT ANGLE
0° TO 15°	15°
15° TO 25°	SAME AS LATITUDE
25° TO 30°	SAME AS LATITUDE +5°
30° TO 35°	SAME AS LATITUDE +10°
35° TO 40°	SAME AS LATITUDE +15°
40° +	SAME AS LATITUDE +20°

Table 1:

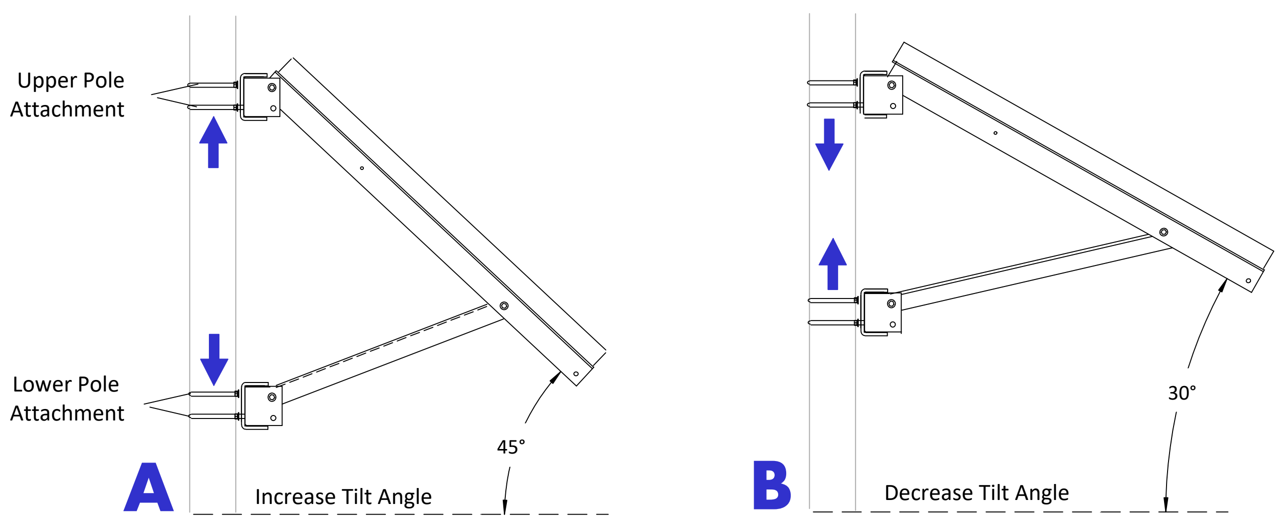


Figure 3. Tilt Angle Adjustments.

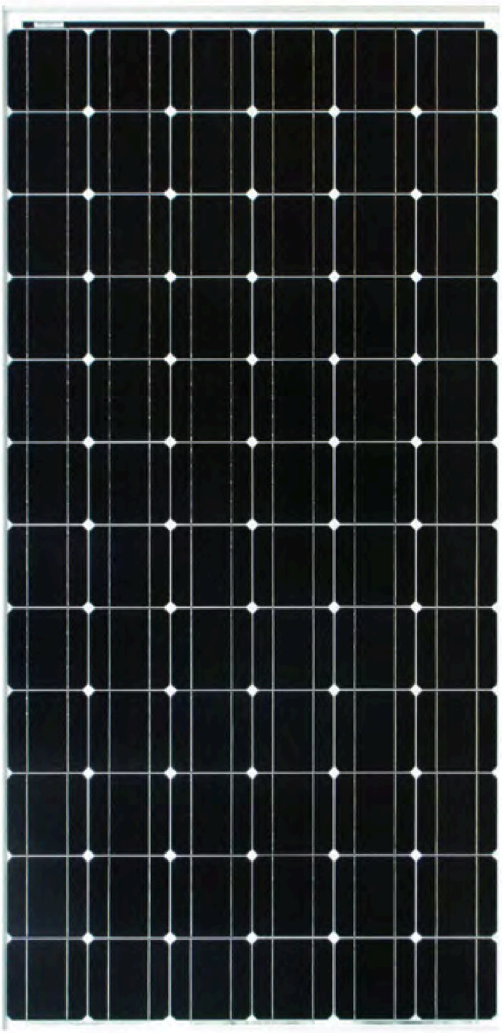
Locate array in an unshaded area facing equator and tilted from the horizontal at desired tilt angle (See Table 1).

Solar arrays in the Northern Hemisphere face South for optimum energy production. Solar Arrays in the Southern hemisphere face North.

When choosing a site, avoid trees, overhead power lines, buildings or obstructions which could cast shadows on the solar modules. This is especially true during the winter months when the arc of the sun is lowest to the horizon.

190W and 200W Photovoltaic modules

4190J - 4200J



Module appearance may vary.
Cells have rounded corners with either 165 or 150mm diameter.

Our latest generation of small area modules offers the following benefits:

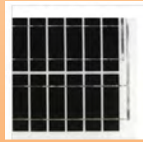
Built to last

From mountaintops to off-shore platforms, on weather stations in the bitter cold of Antarctica and on telephone signal repeaters in the hot Australian outback, the technology has been proven in the harshest environments.

Accessible junction box for off grid connections

J-type junction box has accessible terminals for easier module interconnections in off grid applications, and it allows fitting cable glands for various cable sections.

High reliability



Cell interconnections and diode placement use well-established industry practice and are field-proven to provide excellent reliability.

Thick, durable, scratch resistant back sheet

The thick back sheet provides extra insulation and increased resistance to protect your module against rough handling. The white polyester material lasts longer and increases energy production.

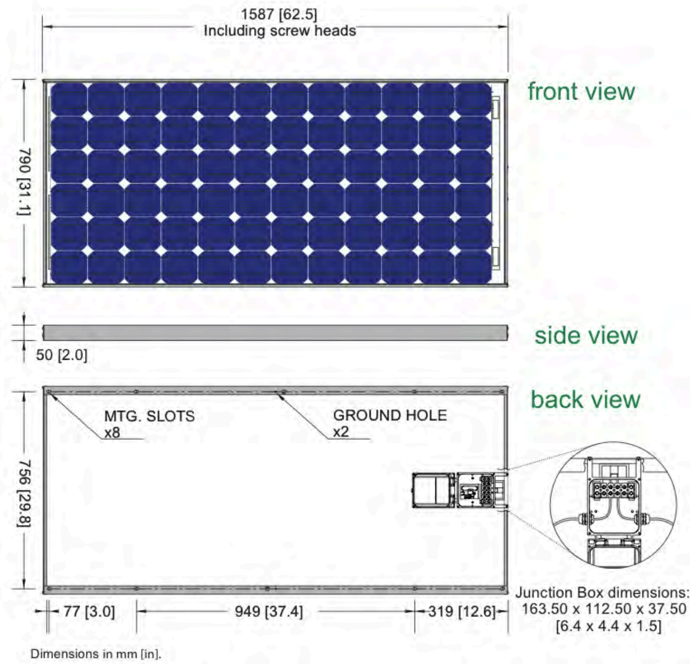
190W and 200W Photovoltaic modules – **4190J -4200J**

Electrical characteristics

	4190J (1) STC 1000W/m²	4190J (2) NOCT 800W/m²	4200J (1) STC 1000W/m²	4200J (2) NOCT 800W/m²
Maximum power (P_{max})	190W	137W	200W	144W
Voltage at Pmax (V_{mpp})	38.0V	33.8V	38.0V	34.0V
Current at Pmax (I_{mpp})	5.0A	3.82A	5.3A	4.2A
Short circuit current (I_{sc})	5.5A	4.33A	5.8A	4.7A
Open circuit voltage (V_{oc})	45.3V	40.2V	45.3V	41.0V
Module efficiency	15.2%	-	16.0%	-
Tolerance Pmax	± 5%	-	± 5%	-
Nominal voltage	24V	-	12V	-
Efficiency reduction at 200W/m²	<5% reduction (efficiency 14.4%)		<5% reduction (efficiency 15.2%)	
Limiting reverse current	5.5A		5.56A	
Temperature coefficient of I_{sc}	0.105%/ °C			
Temperature coefficient of V_{oc}	-0.360%/ °C			
Temperature coefficient of P_{max}	-0.45%/ °C			
(3) NOCT	47 ±2 °C			
Maximum series fuse rating	20A			
Application class	Class A (according to IEC 61730-2007)			
Maximum system voltage	600V (U.S. NEC) 1000V (IEC 61730:2007)			

1: Values at Standard Test Conditions (STC): 1000W/m² irradiance, AM1.5 solar spectrum and 25°C module temperature
2: Values at 800W/m² irradiance, Nominal Operation Cell Temperature (NOCT) and AM1.5 solar spectrum
3: Nominal Operation Cell Temperature: Module operation temperature at 800W/m² irradiance, 20°C air temperature, 1m/s wind speed

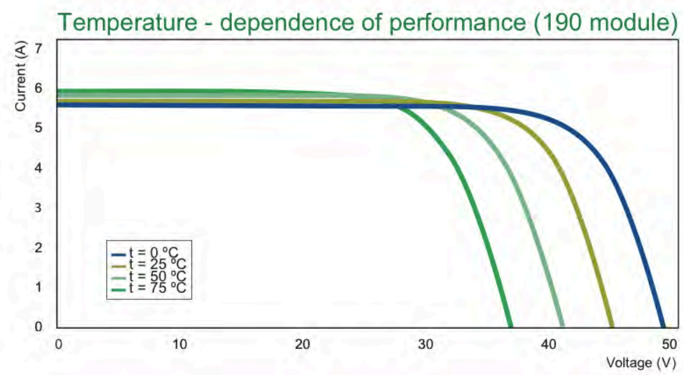
All solar modules are individually tested prior to shipment; an allowance is made within our factory measurement to account for the typical power degradation (LILD effect) which occurs during the first few days of deployment.

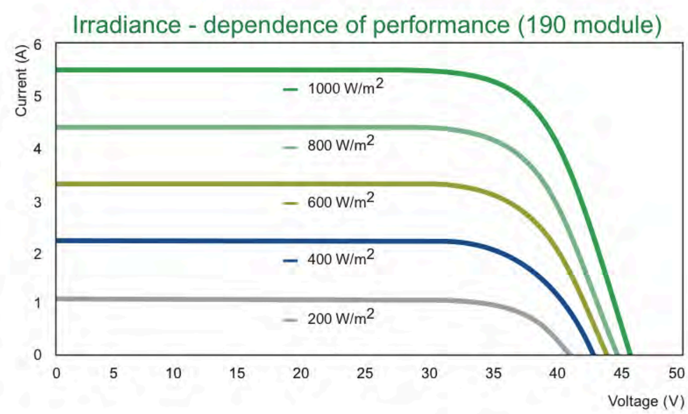


SES MAPPS Solar Module Mechanical characteristics

Solar cells	72 monocrystalline 5" silicon cells (125x125mm) in series
Front cover	High transmission 3.2mm (1/8") glass
Encapsulant	EVA
Back cover	White polyester
Frame	Silver anodized aluminum (Universal II)
Junction box	IP65 with 4 terminal screw connection block; accepts PG 13.5, M20 13mm (½") conduit, or cable fittings accepting 6-12mm diameter cable.
Terminals	accept 2.5-10mm2 (8-14 AWG) wire
Dimensions	1587 x 790 x 50mm / 62.5 x 31.1 x 2in
Weight	15.4kg / 33.95lbs

All dimensional tolerances within ±1% unless otherwise stated.





Warranty*

- Free from defects in materials and workmanship for 2 years
- 90% Min power output for 12 years
- 25 year warranty optional *Refer to limited warranty certificate for terms and conditions

SES MAPPS Solar Module Certification

Certified according to the extended version of the IEC 61215 (ed. 2), EC 61215:2005-08 (Crystalline silicon terrestrial photovoltaic modules - Design qualification and type approval)

Certified according to IEC 61730-1 and IEC 61730-2 (ed. 1), EN 61730-1:2007-05 and EN 61730-2:2007-05. (Photovoltaic module safety qualification, requirements for construction and testing).

Listed to UL 1703 & ULC ORD-C1703 Standard for Safety by Intertek ETL. Class C Fire Rating.

Approved by Intertek ETL according to FM 3611, Dec 2004, and according to CAN/CSA C22.2 No. 213-M1987, 1st Edition, Reaffirmed 2004, for use in a Class I, Division 2, Group A, B, C, D Hazardous (Classified) Location.

SOLAR ELECTRIC SUPPLY, INC.
SINCE 1996

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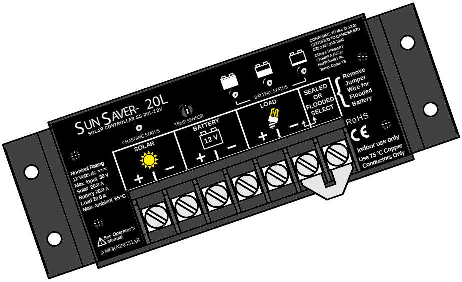
SUNSAVER

PV SYSTEM CONTROLLERS

Installation and Operation Manual



SunSaver Models Included in this Manual:

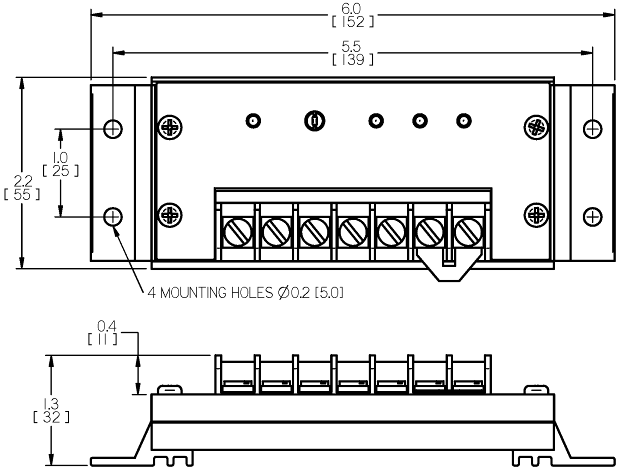
- **SS-6-12V / SS-6L-12V**
- **SS-10-12V**
- **SS-10L-12V / SS-10L-24V**
- **SS-20L-12V / SS-20L-24V**

MORNINGSTAR

World's Leading Solar Controllers & Inverters

www.morningstarcorp.com

SunSaver Dimensions
Inches [Millimeters]



Specification Summary

Ratings	SS-6/6L	SS-10/10L	SS-20L
System Voltage	12 V	12 or 24V	12 or 24V
Min. Battery Voltage	6 V	6 V	6 V
Max. Solar Voltage	30 V	30 or 60V	30 or 60V
Max. Solar Current	6 .5 A	10 A	20 A
Max. Load Current	6 A	10 A	20 A

See Section 7.0 for full technical specifications

*** Array voltage should never exceed maximum input voltage. Refer to the solar module documentation to determine the highest expected array V_{oc} as defined by the lowest expected ambient temperature for the system location.*

CONTENTS

1.0 IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS.

This manual contains important safety, installation and operating instructions for the SunSaver solar controller.

The following symbols are used throughout this manual to indicate potentially dangerous conditions or mark important safety instructions:

WARNING:
Indicates a potentially dangerous condition. Use extreme caution when performing this task.

CAUTION:
Indicates a critical procedure for safe and proper operation of the controller.

NOTE:
Indicates a procedure or function that is important for the safe and proper operation of the controller.

Safety Information

- Read all of the instructions and cautions in the manual before beginning installation.
- There are no user serviceable parts inside the SunSaver. Do not disassemble or attempt to repair the controller.
- Disconnect all sources of power to the controller before installing or adjusting the SunSaver.
- There are no fuses or disconnects inside the SunSaver. Do not attempt to repair.
- Install external fuses/breakers as required.

WARNING:
These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any servicing other than that specified in the operating instructions unless you are qualified to do so.

WARNING:
EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

CAUTION:
A BATTERY CAN PRESENT A RISK OF ELECTRICAL SHOCK, BURN FROM HIGH SHORT-CIRCUIT CURRENT, FIRE OR EXPLOSION FROM VENTED GASES. OBSERVE PROPER PRECAUTIONS

CAUTION:
To reduce the risk of fire, connect only to a circuit provided with a maximum branch-circuit overcurrent protection rating not to exceed the model current rating on page 2 and in accordance with the National Electrical Code, ANSI/NFPA 70.

CAUTION:
Unit has no battery removal protection. Disconnecting battery during charging may cause a brief spike in load voltage (above the 15V regulation limit) which may damage sensitive equipment.

NOTE:
PROPER DISPOSAL OF BATTERIES IS REQUIRED. REFER TO YOUR LOCAL CODES FOR DISPOSAL REQUIREMENTS

Informations de sécurité

- Lisez toutes les instructions et les avertissements figurant dans le manuel avant de commencer l'installation.
- Le SunSaver ne contient aucune pièce réparable par l'utilisateur. Ne démontez pas ni ne tentez de réparer le contrôleur.
- Déconnectez toutes les sources d'alimentation du contrôleur avant d'installer ou de régler le SunSaver.
- Le SunSaver ne contient aucun fusible ou interrupteur. Ne tentez pas de réparer.
- Installez des fusibles/coupe-circuits externes selon le besoin.

AVERTISSEMENT:
Ces instructions d'entretien sont exclusivement réservé-es à des techniciens qualifiés. Pour réduire le risque de choc électrique, ne réalisez aucun entretien autre que celui stipulé dans les instructions de fonctionnement, à moins que vous ne possédiez les qualifications néces-saires en la matière.

ATTENTION:
UNE BATTERIE PEUT PRÉSENTER UN RISQUE ÉLEVÉ DE CHOC ÉLECTRIQUE, DE BRÛLURES SUITE À UN COURANT DE COURT-CIRCUIT ÉLEVÉ, À UN INCENDIE OU À UNE EXPLOSION PROVENANT DE GAZ REJETÉS DANS L'AIR. VEUILLEZ PRENDRE LES PRÉCAUTIONS NÉCESSAIRES.

AVERTISSEMENT:
RISQUE D'EXPLOSION. NE PAS DEBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'AGISSE D'UN EMPLACEMENT NON DANGEREUX.

ATTENTION:
Pour diminuer le risque d'incendie, ne connectez l'alimentation qu'à un circuit équipé d'une protection maximum par dérivation contre les surintensités ne dépassant pas le courant nominal du modèle de la page 2, conformément à la norme du Code National de l'Électricité (NEC), ANSI/NFPA 70.

ATTENTION:
Unité bénéficie d'aucune protection de retrait de batterie. Débrancher la batterie pendant la charge peut entraîner un bref pic de tension de charge (au-dessus du 15V limite ***de règlement) qui peuvent endommager les équipement sensibles.***

Installation Safety Precautions

WARNING:
This unit is not provided with a GFDI device. This charge controller must be used with an external GFDI device as required by the Article 690 of the National Electrical Code for the installation location.

- Mount the SunSaver indoors. Prevent exposure to the elements and do not allow water to enter the controller.
- Install the SunSaver in a location that prevents casual contact. The SunSaver heatsink can become very hot during operation.
- Use insulated tools when working with batteries.
- Avoid wearing jewelry during installation.
- The battery bank must be comprised of batteries of same type, make, and age.
- Do not smoke in the vicinity of the battery bank.
- Mount the controller at least 3 ft (1 m) away from vented batteries unless separated by a barrier or located in a separate compartment.

- Power connections must remain tight to avoid excessive heating from a loose connection.
- Use properly sized conductors and circuit interrupters
- This charge controller is to be connected to DC circuits only. These DC connections are identified by the symbol below:

Direct Current Symbol

Précautions de sécurité d’installation

AVERTISSEMENT:
L’appareil n’est pas fourni avec un dispositif GFDI. Ce contrôleur de charge doit être utilisé avec un dispositif GFDI externe tel que requis par l’Article 690 du Code électrique national de l’emplacement de l’installation.

- Montez le SunSaver à l’intérieur. Empêchez l’exposition aux éléments et la pénétration d’eau dans le contrôleur.
- Installez le SunSaver dans un endroit qui empêche le contact occasionnel. Le dissipateur de chaleur SunSaver peut devenir très chaude pendant le fonctionnement
- Utilisez des outils isolés pour travailler avec les batteries.
- Évitez le port de bijoux pendant l’installation.
- Le groupe de batteries doit être constitué de batteries du même type, fabricant et âge.
- Ne fumez pas à proximité du groupe de batteries.
- Monter le régulateur au moins 3 pi (1 m) de batteries ventilés sauf séparées par une barrière ou situé dans un compartiment séparé.

- Les connexions d’alimentation doivent rester serrées pour éviter une surchauffe excessive d’une connexion desserrée.
- Utilisez des conducteurs et des coupe-circuits de dimensions adaptées.
- Ce contrôleur de charge ne doit être connecté qu’à des circuits en courant continu. Ces connexions CC sont identifiées par le symbole ci-dessous:

Symbole courant continu

2.0 GENERAL INFORMATION

2.1 Overview

Thank you for selecting the SunSaver solar charge controller. The SunSaver is an advanced PWM solar battery charger and load controller for stand-alone PV systems.

The SunSaver battery charging process has been optimized for long battery life and improved system performance. Self-diagnostics and electronic error protection prevent damage when installation mistakes or system faults occur.

Although the SunSaver is very simple to install and use, please take the time to read this operator’s manual and become familiar with the controller.

2.2 Features

The features of the SunSaver are shown in Figure 1 below. An explanation of each feature is provided.

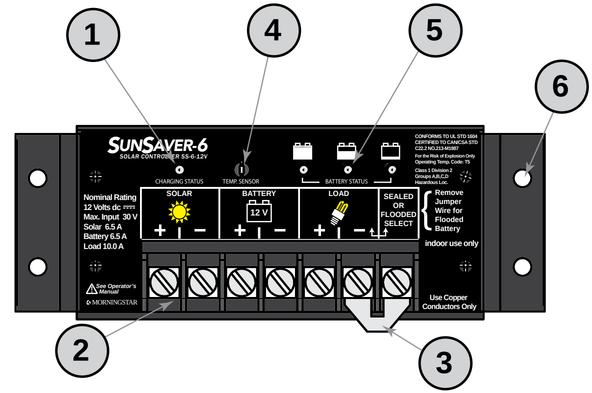


Figure 1. SunSaver features.

1 - Status LED

An LED indicator that shows charging status and also indicates when a solar input fault condition exists.

2 - Power Terminal Block

Power terminations for system Solar, Battery, and Load connections.

3 - Battery Select Jumper

A removable jumper to select the battery type.

4 - Local Temperature Sensor

Measures ambient temperature. Battery regulation is adjusted based on ambient temperature changes.

5 - Battery Status LEDs

Provides approximate battery *state-of-charge* indication and also indicates when a system or load fault condition exists.

6 - Mounting Holes

Four (4) mounting holes

2.3 Regulatory Information

NOTE:
This section contains important information for safety and regulatory requirements.

The SunSaver controller should be installed by a qualified technician according to the electrical regulations of the country in which the product will be installed.

SunSaver controllers comply with the following EMC standards:

- Immunity: EN61000-6-2:1999
- Emissions: EN55022:1994 with A1 and A3 Class B1
- Safety: EN60335-1 and EN60335-2-29 (battery chargers)

FCC requirements:

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by Morningstar for compliance could void the user's authority to operate the equipment.

Note:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment on and off, the user is encouraged to try to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for assistance.

This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numerique de la classe B est conforme a la norme NMB-003 du Canada.

3.0 INSTALLATION INSTRUCTIONS

3.1 General Installation Notes

- Read through the entire installation section before beginning installation.
- Be very careful when working with batteries. Wear eye protection. Have fresh water available to wash and clean any contact with battery acid.
- Use insulated tools and avoid placing metal objects near the batteries.
- Explosive battery gases may be present during charging. Be certain there is sufficient ventilation to release the gases.
- Do not install in locations where water can enter the controller.
- Loose power connections and/or corroded wires may result in resistive connections that melt wire insulation, burn surrounding materials, or **even cause fire**. Ensure tight connections and use cable clamps to secure cables and prevent them from swaying in mobile applications.
- The SunSaver charging algorithm is compatible with lead-acid or NiCd batteries. ***NiMH, Li-ion, and other battery chemistries are not compatible with the SunSaver charging algorithm.***
- The SunSaver Battery connection may be wired to one battery or a bank of batteries. The following instructions refer to a singular battery, but it is implied that the battery connection can be made to either one battery or a group of batteries in a battery bank.

Installation in Hazardous Locations

THIS EQUIPMENT IS ONLY SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A,B,C and D OR NON-HAZARDOUS LOCATIONS.

CAUTION:

For hazardous locations, device must be installed inside an appropriately type rated tool secured enclosure. Consult with local authority having jurisdiction for type rating required.

ATTENTION:

Pour les endroits dangereux, le dispositif doit être installé à l'intérieur un convenablement qualification de type outil sécurisé enceinte. Consultez les autorités locales compétentes pour la qualification de type requise.

3.2 User Selections

Select a Battery Type

The SunSaver provides a *Battery Select Jumper* to choose the battery type. See *Section 7.0 Technical Specifications* for detailed charging information for each battery type.

The battery select jumper is secured in the terminal block between terminal #6 and terminal #7 as shown in figure 2a. The second column in table 1 specifies whether the jumper should be removed or remain in place, depending on the desired battery type.

Battery Type	Battery Jumper	Absorption	Float	Equalize
Sealed	Inserted	14.10V	13.70V	N/A
Flooded/ AGM[1]	Removed	14.60V	13.70V	14.90V

1. Flooded/AGM absorption value effective with unit serial nos. 2038 0001 and higher

Table 1. Battery Type selection

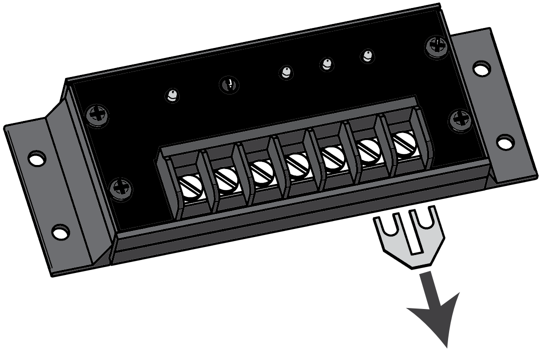


Figure 2a. Removing the Battery Select jumper.

Choose Regulation Method (optional)

Choose between *Pulse Width Modulation* (PWM) charging or *Slow Switching* charging. PWM charging is the default regulation method and is the <u>method recommended for most systems</u>.

Slow Switching regulation should only be selected if noise or interference exists in the system due to PWM charging. This regulation method limits the switching frequency to 10 Hz (maximum), which can eliminate noise issues in some systems.

PWM charging is selected by default. To enable *Slow Switching* regulation do the following:

1. Remove all four screws that secure the faceplate on the SunSaver. See Figure 2b.
2. Gently pry the faceplate off the SunSaver. Occasionally, epoxy encapsulant will cause the faceplate to stick. Use a small flat-head screw driver to separate the faceplate from the SunSaver body. See Figure 2c.
3. A loop of wire protrudes from the epoxy. Cut the loop with wire clippers to switch the regulation method to Slow Switching. See Figure 2d.
4. Tape the cut ends with electrical tape to prevent contact with the faceplate.
5. Replace the faceplate and secure with the four screws.

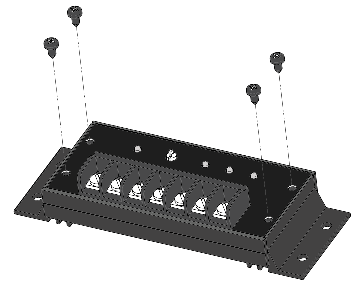


Figure 2b. Remove faceplate screws.

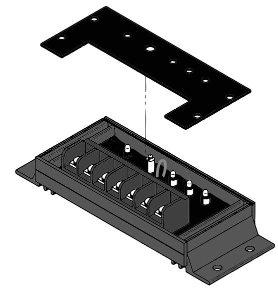


Figure 2c. Remove faceplate.

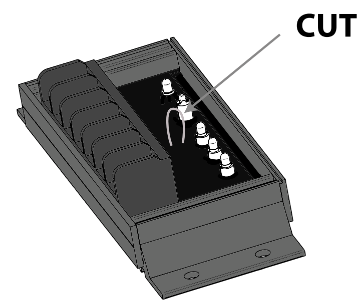


Figure 2d. Cut the Regulation Select wire loop.

3.3 Mounting

CAUTION: Equipment Damage or Risk of Explosion
Never install the SunSaver in an enclosure with vented/ flooded batteries. Battery fumes are flammable and will corrode and destroy the SunSaver circuits.

CAUTION: Equipment Damage
When installing the SunSaver in an enclosure, ensure sufficient ventilation. Installation in a sealed enclosure will lead to over-heating and a decreased product lifetime.

PRUDENCE: Endommagement de l’équipement ou risque d’explosion
N’installez jamais le SunSaver dans une enceinte avec des batteries à évent/à électrolyte liquide. Les vapeurs des batteries sont inflammables et corroderont et détruiront les circuits du SunSaver.

PRUDENCE: Endommagement de l’équipement
Assurez une ventilation suffisante en cas d’installation du SunSaver dans une enceinte. L’installation dans une enceinte hermétique entraîne une surchauffe et une réduction de la durée de vie du produit.

Step 1: Choose Mounting Location

Locate the SunSaver on a vertical surface protected from direct sun, high temperatures, and water. The unit should be located in the same ambient temperature as the battery. Locate the controller within 10 ft (3 M) of the battery bank. Mounting the controller on a horizontal surface does not provide optimal airflow and could lead to overheating.

Step 2: Check for Clearance

Place the SunSaver in the location where it will be mounted. Verify that there is sufficient room to run wires and that there is ample room above and below the controller for air flow.

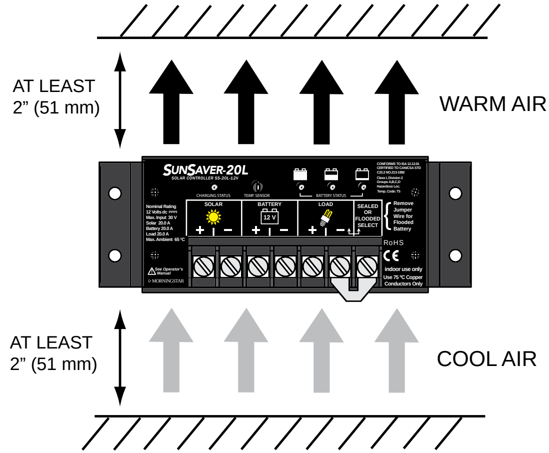


Figure 3. Mounting and cooling.

Step 3: Mark Holes

Use a pencil or pen to mark the four (4) mounting hole locations on the mounting surface.

Step 4: Drill Holes

Remove the controller and drill 3/32” (2.5 mm) holes in the marked locations.

Step 5: Secure Controller

Place the controller on the surface and align the mounting holes with the drilled holes in step 4. Secure the controller in place using mounting screws (not included).

3.4 Wiring

NOTE: A recommended connection order has been provided for maximum safety during installation. When disconnecting, solar input must be removed first before disconnecting battery. See caution below.

NOTE: The SunSaver is a negative ground controller. Any <u>one</u> negative conductor can be earth grounded as required. Grounding is recommended, but not required for correct operation.

NOTE:
To comply with the NEC, the SunSaver must be installed using wiring methods in accordance with Article 690 of the latest edition of the National Electric Code, NFPA 70.

NOTE:
The total current draw of all system loads connected to the SunSaver LOAD terminals cannot exceed the controller's load current rating.

NOTE:
For mobile applications, be sure to secure all wiring. Use cable clamps to prevent cables from swaying when the vehicle is in motion. Unsecured cables create loose and resistive connections which <u>may lead to excessive heating and/or fire.</u>

WARNING:
EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

AVERTISSEMENT:
RISQUE D'EXPLOSION. NE PAS DEBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'AGISSE D'UN EMPLACEMENT NON DANGEREUX.

CAUTION: Unit has no battery removal protection. Disconnecting battery during charging may cause a brief spike in load voltage (above the 15V regulation limit) which may damage sensitive equipment.

ATTENTION:
Unité bénéficie d'aucune protection de retrait de batterie. Débrancher la batterie pendant la charge peut entraîner un bref pic de tension de charge (au-dessus du 15V limite *de règlement) qui peuvent endommager les équipement sensibles.*

Step 1: Load Wiring

The SunSaver load output connection will provide battery voltage to system loads such as lights, pumps, motors, and electronic devices. See *Section 4.3 Load Control Information* for more details about load control.

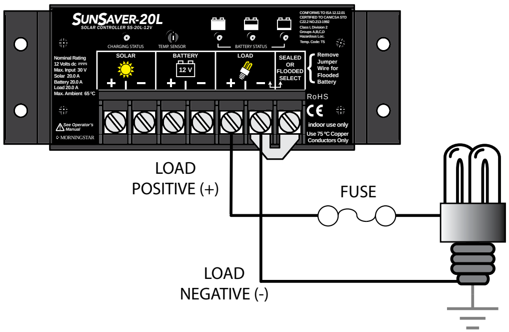


Figure 4. Load wiring.

Connect load positive (+) and negative (-) load wires to the system load(s) or load distribution panel as shown in figure 4. Refer to the wire gauge chart on page 30 of this manual for correct wire size. Use 75 °C copper wire.

If required, the negative load connection may be earth grounded. Use appropriate gauge wire and proper grounding methods for the installation site.

An in-line fuse holder should be wired in series in the load positive (+) wire as shown. DO NOT INSERT A FUSE AT THIS TIME. A circuit breaker may be used in lieu of a fuse. Keep the breaker in the open (disconnected) position at this time.

If wiring the load connection to a distribution panel, each load circuit should be fused separately. The total load draw should not exceed the the SunSaver's maximum load rating.

Step 2: Battery Wiring

WARNING: Shock Hazard
Fuses, circuit breakers, and disconnect switches should never open grounded system conductors. Only GFDI devices are permitted to disconnect grounded conductors.

AVERTISSEMENT: Risque de décharge électrique
Les fusibles, coupe-circuits et interrupteurs ne doivent jamais ouvrir les conducteurs du système mis à la terre. Seuls les dispositifs GFDI sont autorisés à déconnecter les conducteurs reliés mis à la terre.

The nominal battery voltage must match the SunSaver voltage rating. For 12V SunSaver models, only a 12V battery may be used. Connect only 24V batteries (or two 12V batteries in series) to 24V SunSaver models.

Before connecting the battery, measure the battery voltage. Battery voltage must be greater than 6 volts to power the SunSaver (12V or 24V models).

Connect the battery to the SunSaver. Refer to the wire gauge chart on page 43 of this manual for correct wire size. Use 75 °C copper wire.

If required, the negative battery connection may be earth grounded. Use appropriate gauge wire and proper grounding methods for the installation site.

Wire an in-line fuse holder no more than 6 inches (150 mm) from the battery positive terminal. DO NOT INSERT A FUSE AT THIS TIME. A circuit breaker may be used in lieu of a fuse. Keep the breaker in the open (disconnected) position at this time.

CAUTION: Unit has no battery removal protection. Disconnecting battery during charging may cause a brief spike in load voltage (above the 15V regulation limit) which may damage sensitive equipment.

***ATTENTION*:**
Unité bénéficie d'aucune protection de retrait de batterie. Débrancher la batterie pendant la charge peut entraîner un bref pic de tension de charge (au-dessus du 15V limite *de règlement) qui peuvent endommager les équipement sensibles.*

NOTE:
Battery circuit fuse / breaker not included. Fuse must be purchased separately.

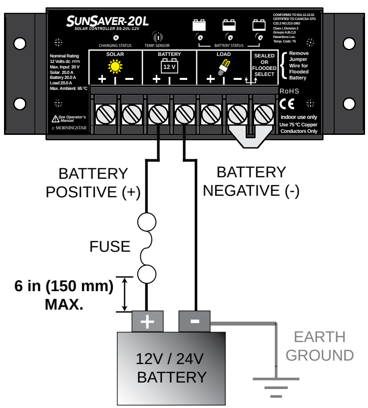


Figure 5. Battery wiring.

Step 3: Solar Wiring

WARNING: Shock Hazard
The solar PV array can produce open-circuit voltages in excess of 40 Vdc when in sunlight. Verify that the solar input breaker or disconnect has been opened (disconnected) before installing the system wires.

AVERTISSEMENT: Risque de décharge électrique
Le réseau PV solaire peut produire des tensions de circuit ouvert supérieures à 40 V cc à la lumière du soleil. Vérifiez que le coupe-circuit ou l'interrupteur d'entrée solaire a été ouvert (déconnexion) avant d'installer les câbles du système.

WARNING: Risk of Damage
Connecting the solar array to the battery terminal will <u>permanently damage</u> the SunSaver.

AVERTISSEMENT : Risque d'endommagement
La connexion du réseau solaire sur la borne de la batterie endommagera le SunSaver de façon permanente.

The nominal solar module voltage must match the SunSaver voltage rating. For 12V SunSaver models, only a 12 V nominal solar module having a maximum open circuit voltage of 30V may be used. Connect only 24V nominal solar modules (or two 12V arrays in series) to 24V SunSaver models. The maximum open circuit voltage of the 24V array must be less than 60V.

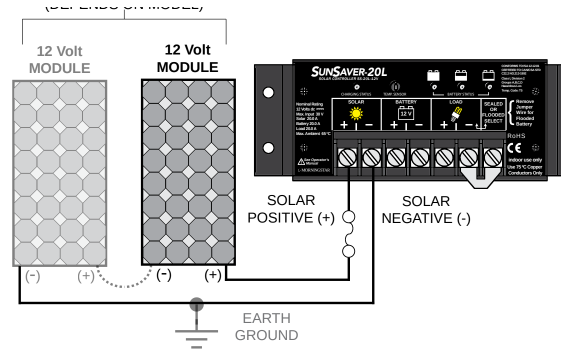


Figure 6. Solar input wiring.

NOTE:
Higher voltage PV modules designed for on-grid PV applications should not be used with the SunSaver or any PWM controller. Only use high voltage modules with maximum power point tracking (MPPT) controllers.

Connect the solar module(s) to the SunSaver. Refer to the wire gauge chart on page 30 of this manual for correct wire size. Use 75 °C copper wire.

If required, the negative solar connection may be earth grounded. Use appropriate gauge wire and proper grounding methods for the installation site.

Step 4: Confirm Wiring

Re-check the wiring in steps 1 through 3. Confirm correct polarity at each connection. Verify that all seven (7) SunSaver power terminals are tightened.

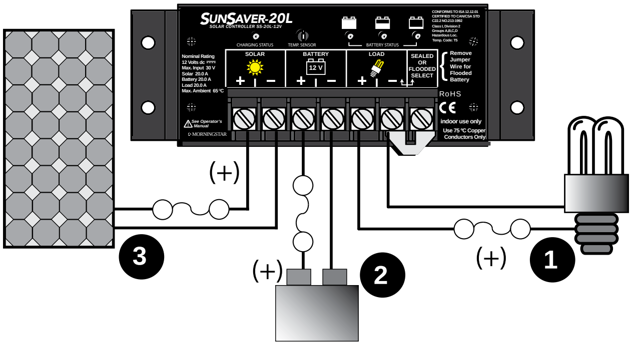


Figure 7. System Wiring Review.

Step 5: Install the Terminal Cover

The terminal cover prevents contact with the power terminals when energized. ***UL / ETL Listed systems must install the terminal cover.*** The terminal cover installation is optional for systems that are not listed to UL / ETL.

Begin by removing the two (2) lower faceplate screws as shown in figure 8a. Set the screws aside.

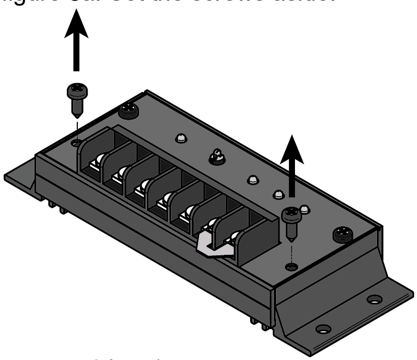


Figure 8a. Remove 2 faceplate screws.

Next, place the terminal cover over the terminal block as shown in Figure 8b. The cover mounting holes should align with the two (2) faceplate screw holes.

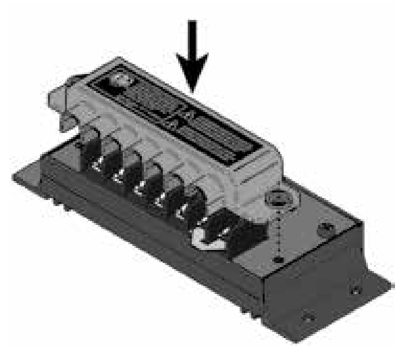


Figure 8b. Place the Terminal Block Cover.

Last, secure the terminal cover with the two (2) screws included with the cover.

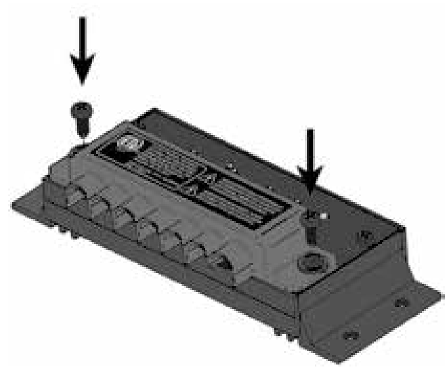


Figure 8c. Secure the Terminal Block Cover with 2 screws.

3.0

Step 6: Install Fuses or Close Breakers

Install a properly sized DC-rated fuse in each fuse holder in the following order:

1. Load circuit
2. Battery circuit
3. Solar circuit

Refer to the fuse table on page 46 for appropriate fuse sizes

If using circuit breakers, close the load breaker first followed by the battery breaker, then the solar breaker.

Step 7: Confirm Power-up

The SunSaver should begin the power-up LED sequence when battery power is applied. Observe that the Battery Status LEDs blink in sequence one time.

If the SunSaver does not power up or a flashing LED error sequence exists, refer to *Section 5.0 Troubleshooting.*

4.0 OPERATION

4.1 LED Indications

STATUS LED

The Status LED indicates charging status and any existing solar input error conditions. The Status LED is on when charging during the day and off at night. The Status LED will flash red whenever an error condition(s) exists. Table 2 lists the Status LED indications.

Color	Indication	Operating State
None	Off (with heartbeat[1])	Night
Green	On Solid (with heartbeat[2])	Charging
Red	Flashing	Error
Red	On Solid (with heartbeat[2])	Critical Error

[1] Status LED heartbeat indication flickers ON briefly every 5 seconds
[2] Status LED heartbeat indication flickers OFF briefly every 5 seconds

Table 2. Status LED definitions

For more information on Status LED errors, see *Section 5.1 Error Indications*.

4.0

BATTERY SOC LEDS

Three (3) battery "state-of-charge" (SOC) LEDs indicate the level of charge on the battery. The SOC indication is based only on battery voltage setpoints, which only provides an approximation of the actual state-of-charge of the battery. Table 3 lists the SOC LED indications.

SOC LED	Indication	Battery Status	Load Status
Green	Fast Flashing (2 Flash / sec)	Full Battery: Equalize Charge	Load On
Green	Med. Flashing (1 Flash / sec)	Full Battery: Absorption Charge	Load On
Green	Slow Flashing (1 Flash / 2 sec)	Full Battery: Float Charge	Load On
Green	On solid	Battery Nearly Full	Load On
Yellow	On solid	Battery Half Full	Load On
Red	Flashing (1 Flash / sec)	Battery Low	LVD Warning (Load On)
Red	On solid	Battery Empty	LVD (Load Off)
None	No LEDS On	Battery Missing	Load Off

Table 3. Battery SOC LED definitions

NOTE:
An error condition exists if <u>multiple</u> Battery SOC LEDs are flashing. See Section 5.1 Error Indications for more information.

4.2 Battery Charging Information

The SunSaver has a 4-stage battery charging algorithm for rapid, efficient, and safe battery charging. Figure 9 shows the sequence of the stages.

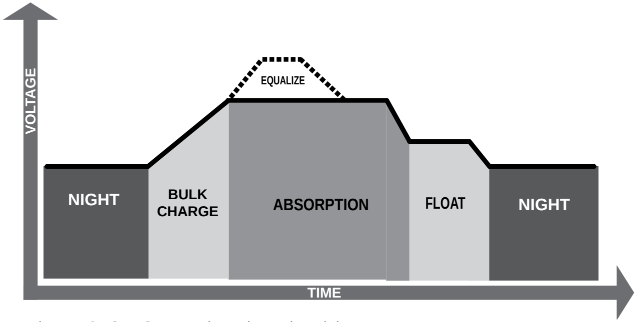


Figure 9. SunSaver charging algorithm.

Bulk Charge

In this stage, the battery voltage has not yet reached absorption voltage and 100% of available solar power is used to recharge the battery.

Absorption

When the battery has recharged to the Absorption voltage setpoint, constant-voltage regulation is used to prevent heating and excessive battery gassing.

Float

After the battery is fully charged the SunSaver reduces the battery voltage to a float charge which is sometimes called a *trickle charge.*

Depending on battery history, the battery remains in the absorption stage for 3 or 4 hours before transitioning to the float stage.

Equalize (flooded battery type only)

The SunSaver will equalize a flooded battery for three (3) hours every 28 days. Equalize charging raises the battery voltage above the standard absorption voltage so that the electrolyte gases. This process prevents electrolyte stratification and equalizes the individual cell voltages within the battery.

WARNING: Risk of Explosion
Equalizing vented batteries produces explosive gases. The battery bank must be properly ventilated.

CAUTION: Equipment Damage
Excessive overcharging and gassing too vigorously can damage the battery plates and cause shedding of active material from the plates. An equalization that is too high or for too long can be damaging. Review the requirements for the particular battery being used in your system.

AVERTISSEMENT: Risque d'explosion
Les batteries à évent et compensation produisent des gaz explosifs. Le groupe de batteries doit être correctement ventilé.

ATTENTION: Endommagement de l'équipement
Une surcharge excessive et un dégagement gazeux trop vigoureux peuvent endommager les plaques de batteries et provoquer l'élimination du matériau actif des plaques. Une compensation trop élevée ou trop longue peut provoquer des dégâts. Examinez les exigences pour la batterie particulière utilisée dans votre système.

Dead Battery Charging

The SunSaver has a special charging function to recover batteries that have discharged too low. If the terminal voltage of the battery is greater than 1 Volt, the SunSaver

will detect the battery and provide approximately 85% of available charge current until the battery reaches the minimum operating voltage of the controller. When the battery has recharged to the minimum operating voltage of the SunSaver, 100% of available charge current will flow to the battery and normal operation will resume.

4.3 Load Control Information

The primary purpose of the load control function is to disconnect system loads when the battery has discharged to a low state-of-charge and reconnect system loads when the battery is sufficiently recharged. System loads may be lights, pumps, motors, DC appliances, and other electronic devices. The total current draw of all loads must not exceed the SunSaver maximum load rating.

NOTE:
Do not wire an AC inverter <u>of any size</u> to the load terminals of the SunSaver. Damage to the load control circuit may result. Connect inverters directly to the battery or battery bank.

Load Control Settings

Load control is fully automatic. The load will be disconnected and reconnected based upon the Low Voltage Disconnect (LVD) and Low Voltage Reconnect (LVR) voltage thresholds. The LVD and LVR thresholds are listed in the back of the manual.

LVD Warning

As the battery discharges the *Battery Status* LEDs will transition from green to yellow and then from yellow to flashing red. The flashing red indication is a warning that a low voltage disconnect event will occur soon. The amount of time between a green SOC indication and load disconnect will depend on many factors including:

- rate of discharge (amount of load draw)
- capacity of the battery
- health of the battery
- LVD set-point

If the battery discharges to the LVD set-point the load will disconnect and a solid red Battery Status LED indication will be displayed.

General Load Control Notes

- Only SS-6L/10L/20L models provide load control.
- Regulated voltage due to temperature compensation is limited to a maximum of 15V (30V @ 24V nominal). This protects certain DC loads that may be damaged by high regulated input voltage.
- The load connection is NOT a regulated voltage output. The load terminal voltage is approximately the same as battery voltage unless the controller is in LVD condition (load turned off).
- Do not wire multiple SunSaver load outputs together in parallel to power DC loads with a current draw greater than the lowest rated controller's maximum load rating. Equal current sharing cannot be guaranteed and an over-load condition will likely occur on one or more controllers.
- Exercise caution when connecting loads with specific polarity to a live load circuit. A reverse polarity connection may damage the load. Always re-check load connections before applying power.
- The SunSaver will go straight to LVD on start-up if the battery voltage is at or below 11.7V / 23.4V.

4.4 Protections

Solar Overload

(Charging Status LED: Red flashing) If the solar current exceeds the maximum solar rating, the SunSaver will stop charging until the solar current returns to within its operational rating. See *Section 7.0 Technical Specifications* for more information.

Load Overload

(Battery Status LEDs: G&R - Y sequencing) If the load current exceeds the maximum load current rating, the SunSaver will disconnect the load.

The SunSaver will attempt to reconnect the load two (2) times approximately 10 seconds apart. If the overload remains after the first two (2) attempts, the fault must be cleared by removing and reapplying power.

Solar Short Circuit

(Charging Status LED: off) Solar input power wires are short-circuited. Charging automatically resumes when the short is cleared.

Load Short Circuit

(Battery Status LEDs: G&R - Y sequencing) Fully protected against load wiring short-circuits. After two (2) automatic load reconnect attempts (10 seconds apart), the fault must be cleared by removing and reapplying power.

PV Reverse Polarity

(Charge Status LED: off) Fully protected against reverse solar connection. No damage to the controller will result. Correct the mistake to resume normal operation.

Battery Reverse Polarity

(No LED indication) Fully protected against reverse battery connection. No damage to the controller will result. Correct the mistake to resume normal operation.

Damaged Local Temperature Sensor

(Battery Status LED: R - Y - G sequencing, Charge Status LED: R on solid) The local ambient temperature sensor is short-circuited or damaged. Charging stops to avoid over- or under-charging. This is a critical error. Contact your authorized Morningstar dealer for service.

Damaged Internal Temperature Sensor

(Battery Status LED: R - Y - G sequencing, Charge Status LED: R on solid) The internal heatsink temperature sensor is damaged. This is a critical error. Contact your authorized Morningstar dealer for service.

High Temperature

(Battery Status LED: R - Y sequencing) The heatsink temperature has exceeded 85 °C and the solar and load is disconnected. The SunSaver will automatically reconnect when the heatsink cools to 80 °C.

High Voltage Disconnect

(Battery Status LED: R - G sequencing) The battery voltage has exceeded the controller's maximum regulation limit. The solar and load will be disconnected until the battery voltage decreases to the SunSaver's High Voltage Reconnect threshold. See *Section 7.0 Technical Specifications* for more information.

4.5 Inspection and Maintenance

The following inspections and maintenance tasks are recommended at least two times per year for best controller performance.

- Tighten all terminals. Inspect for loose, broken, or corroded connections.
- Verify that all wire clamps and tie-downs are secure.
- Check that the controller is mounted in a clean, protected environment; free of dirt, insects, nests, and corrosion.
- If applicable, check enclosure ventilation and air flow holes for obstructions.
- Verify LED indication is consistent with the present system conditions.

5.0 TROUBLESHOOTING

5.1 Error Indications

Status LED Error Indications

• Solar overload	Flashing Red
• High Voltage Disconnect	Flashing Red
• High Temperature Disconnect	Flashing Red
• Damaged local temp. sensor	Solid Red[1]
• Damaged heatsink temp. sensor	Solid Red[1]
• Damaged input MOSFETs	Solid Red[1]
• Firmware Error	Solid Red[1]

1 - A heartbeat indication flickers the Status LED off briefly every 5 seconds. A solid red Status LED indicates that a critical fault has been detected. Critical faults typically indicate that the controller is damaged and requires service.

Battery Status LED Error Indications

• High Voltage Disconnect	R - G Sequencing
• High Temperature Disconnect	R - Y Sequencing
• External Wiring Error	R&G - Y Sequencing
• Load Overcurrent	R&G - Y Sequencing
• Load Short Circuit	R&G - Y Sequencing
• Self-test Error	R - Y - G Sequencing

Note:
LED error indications can be interpreted as follows:

“R - G sequencing” means that the Red LED is on, then the Green LED is on, then Red LED is on....

“R&G - Y sequencing” means that both the Red LED and Green LED are on, then just the Yellow LED is on, then Red and Green LED are on....

5.2 Common Problems

Problem: No LED indications
Solution: With a multi-meter, check the voltage at the Battery terminals on the SunSaver and the Solar terminals on the SunSaver. The solar module must be in good sun and battery voltage must be at least 1 V to power the SunSaver and activate the dead battery charging function.

Problem: The SunSaver is not charging the battery.
Solution: If the Status LED is solid or flashing red, see *Section 5.1 Error Indications*. If the Status LED is off, measure the voltage across the Solar input terminals of the SunSaver. Input voltage must be greater than battery voltage. Check fuses and solar wiring connections. The solar module must in full natural sunlight.

Problem: No load output.
Solution: If the battery status indication is Solid Red, the SunSaver is in the Low Voltage Disconnect (LVD) condition. The load will automatically switch on when the battery recharges to the Low Voltage Reconnect (LVR) threshold voltage. See the specifications in section 7.0 for LVD & LVR settings.
NOTE: If the SunSaver model is SS-6-12V or SS-10-12V (no load control feature), the controller may be damaged.

Full testing documentation is available on our website at:

http://support.morningstarcorp.com

6.0 WARRANTY AND CLAIM PROCEDURE

LIMITED WARRANTY Morningstar Solar Controllers and Inverters

All Morningstar Professional Series™ products, except the SureSine™ inverter, are warrantied to be free from defects in materials and workmanship for a period of FIVE (5) years from the date of shipment to the original end user. Warranty on replaced units, or field-replaced components, will be limited only to the duration of the original product coverage.

Morningstar Essentials Series™, and SureSine™ inverter, products are warrantied to be free from defects in materials and workmanship for a period of TWO (2) years from the date of shipment to the original end user. Warranty on replaced units, or field-replaced components, will be limited only to the duration of the original product coverage.

Morningstar will, at its option, repair or replace any such defective units.

WARRANTY EXCLUSIONS AND LIMITATIONS

This warranty does not apply under the following conditions:

- Damage by accident, negligence, abuse or improper use.
- PV or load currents exceeding the ratings of the product.
- Unauthorized product modification or attempted repair
- Damage occurring during shipment
- Damage results from acts of nature such as lightning and weather extremes

THE WARRANTY AND REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHERS, EXPRESS OR IMPLIED. MORNINGSTAR SPECIFICALLY DISCLAIMS ANY AND ALL IMPLIED WARRATIES, INCLUDING, WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. No Morningstar distributor, agent or employee is authorized to make any modification or extension to this warranty.

MORNINGSTAR IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF OF ANY KIND, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DOWN-TIME, GOODWILL OR DAMAGE TO EQUIPMENT OR PROPERTY.

WARRANTY CLAIM PROCEDURE

1. Before proceeding, please refer to product manual, including troubleshooting section.

2. Contacting your authorized Morningstar distributor or dealer from whom you purchased the unit is the first step in the warranty process. Local dealers can often address warranty issues quickly.

3. If supplier is unable to address the issue, please contact Morningstar by e-mail (support@morningstarcorp.com) with:

(A) purchase location - business or company name - and date

(B) full model and serial numbers (SN is 8-digits on unit bar label)

(C) failure behavior, including LED indications

(D) array configuration, panel Pmax, Voc, Vmp, Isc, and battery voltage; these specifications are needed to receive assistance.

(E) multi-meter available (for field troubleshooting)

4. After warranty replacement has been approved and new unit(s) received, please return failed unit(s) using pre-paid shipping label, and follow any product specific instructions if requested by Morningstar Warranty Dept.

5. If instructed by Morningstar, after warranty replacement shipment has been received, return of failed unit(s) is required before further warranty replacements can be considered for the original or future cases.

NOTE: Please do not return units without an RMA or case number. Doing so will increase the time required to resolve your claim.

7.0 TECHNICAL SPECIFICATIONS

Electrical

Nominal system voltage	12 or 24 Vdc
Max. solar input voltage	30 or 60V
Max. solar current	6.5 or 10 or 20A
Battery voltage range	6 -15V or 6-30V
Self-consumption	< 8 mA
Voltage Accuracy	1.0 %
Transient Surge Protection	1500W per connection

Protections (Solar & Load): short circuit, over-current, reverse polarity, high temperature, high voltage

Battery Charging

Regulation Method	4 stage PWM
Temp. Compensation Coefficient	12 V: -30 mV / °C 24 V: -60 mV / °C (25°C reference)
Temp. Compensation Range	- 30°C to + 60°C
Temp. Compensated Set-points	Absorption Float Equalize

Battery Status LEDs

	Falling V	**Rising V**	
G to Y	12.1	13.1	Y to G
Y to Flash R	11.7	12.6	R to Y
Flash R to R	11.5		

Note: Multiply x2 for 24 Volt systems.
Note: Only SunSavers with load control display the Flashing Red LED indication.

Battery Set-points (@ 25°C)

	Sealed 12 V or 24 V	**Flooded/AGM 12 V or 24 V**
Absorption Voltage[1]	14.1 V or 28.2 V	14.6 V or 29.2 V
Absorption Duration[2]	3 hr	3 hr
Float Voltage	13.7 V or 27.4 V	13.7 V or 27.4 V
Equalize Voltage	none	14.9 V or 29.8 V
Equalize Duration	none	3 hrs
Equalize Calendar	none	28 days
Max. Regulation Voltage[3]	15 V or 30 V	
Low Voltage Disconnect	11.5 V or 23.0 V	
Low Voltage Reconnect	12.6 V or 25.2 V	
High Voltage Disconnect	15.3 V or 30.6 V	
High Voltage Reconnect	14 V or 28 V	
Start-Up LVD	11.7 V or 23.4 V	
Instant LVD	10.0 V or 20.0 V	

1. Flooded/AGM absorption values effective with unit serial nos. 2038 0001 or higher
2. Based on typical PWM duty cycle, and depth of discharge - actual duration may vary
3. Not temperature compensated: 15V @ 12 V nominal, 30V @ 24 V nominal

NOTE: Temperature compensation increases regulation voltage in cold temperature. A 15 V (30 V @ 24 V nominal) maximum battery voltage limit prevents damage to sensitive DC loads.

Environmental

Ambient Temperature Range	-40°C to +60°C
Storage temperature	-55°C to +80°C
Humidity	100% N.C.
Enclosure	IP10 (indoor)

Mechanical

Power terminals wire size (max.)	
Solid	#10 AWG / 5 mm2
Multistrand	#10 AWG / 5 mm2
Fine strand	#10 AWG / 5 mm2
Terminal Diameter	0.210 in / 5.4 mm
Power terminals torque (max.)	10.6 in-lb / 1.2 Nm
Dimensions	See inside front cover
Weight (unpacked)	8 oz / 0.23 kg

Certifications

INTERTEK C ETL US LISTED 3094762

UL1741 INVERTERS, CONVERTERS, AND CONTROLLERS AND INTERCONNECTION SYSTEM EQUIPMENT FOR USE WITH DISTRIBUTED ENERGY SOURCES, SECOND EDITION, REVISION THROUGH AND INCLUDING SEP 07, 2016 CSA C22.2#107.1 Issued: 2001/09/01 Ed: 3 (R2011) General Use Power Supplies

CE

ALL COMPONENTS REACH COMPLIANT

Registration, Evaluation and Authorization of Chemicals

UL121201/CSA C22.2 #213 Nonincendive Electrical Equipment for Use in Class I, Division 2 Hazardous (Classified) Locations, Groups A,B,C,D, Temperature Group: T5

EMC Directives

- Immunity: EN61000-6-2:1999
- Emissions: EN55022:1994 with A1 and A3 Class B1
- Safety: EN60335-1 and EN60335-2-29 (battery chargers)

Tables

Fusing Chart

Wire Gauge (AWG)	Max. Fuse Size*
14	15 Amps
12	20 Amps
10	30 Amps

* per 2011 NEC NFPA 70, Article 240. For copper wire only.

* Refer to the wire charts on page 47 for appropriate wire size.

12 VOLT NOMINAL WIRE CHART

Amps	One-way Wire Distance (feet) Wire Gauge (AWG)					One-way Wire Distance (meters) Wire Gauge (mm^2)				
	14	12	10	8	6	2.0	3.0	5.0	8.0	13.0
2	70	112	180	287	456	21	32	53	85	139
4	35	56	90	143	228	10	16	26	42	69
6	24	38	60	96	152	7	10	17	28	46
8	18	28	45	72	114	5	8	13	21	34
10	14	23	36	57	91	4	6	10	17	27
12	12	19	30	48	76	3	5	8	14	23
14	10	16	26	41	65	3	4	7	12	19
16	9	14	23	36	57	3	4	7	10	17
18	8	13	20	32	51	2	3	6	9	15
20	7	11	18	29	46	2	3	5	8	13

3% Voltage drop, Annealed copper wire at 20°C

24 Volt Nominal Wire Chart

Amps	One-way Wire Distance (feet) Wire Gauge (AWG)					One-way Wire Distance (meters) Wire Gauge (mm^2)				
	14	12	10	8	6	2.0	3.0	5.0	8.0	13.0
2	140	224	360	574	912	42	64	107	171	278
4	70	112	180	286	456	21	32	53	85	139
6	48	76	120	191	304	14	21	35	57	92
8	36	56	90	144	228	10	16	26	42	69
10	29	45	72	115	182	8	12	21	34	55
12	24	38	60	96	152	7	10	17	28	46
14	20	32	51	82	130	6	9	15	24	39
16	18	28	45	72	114	5	8	13	21	34
18	16	25	40	64	101	4	7	11	19	30
20	14	23	36	57	91	4	6	10	17	27

3% Voltage drop, Annealed copper wire at 20°C

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World's Leading Solar Controllers & Inverters

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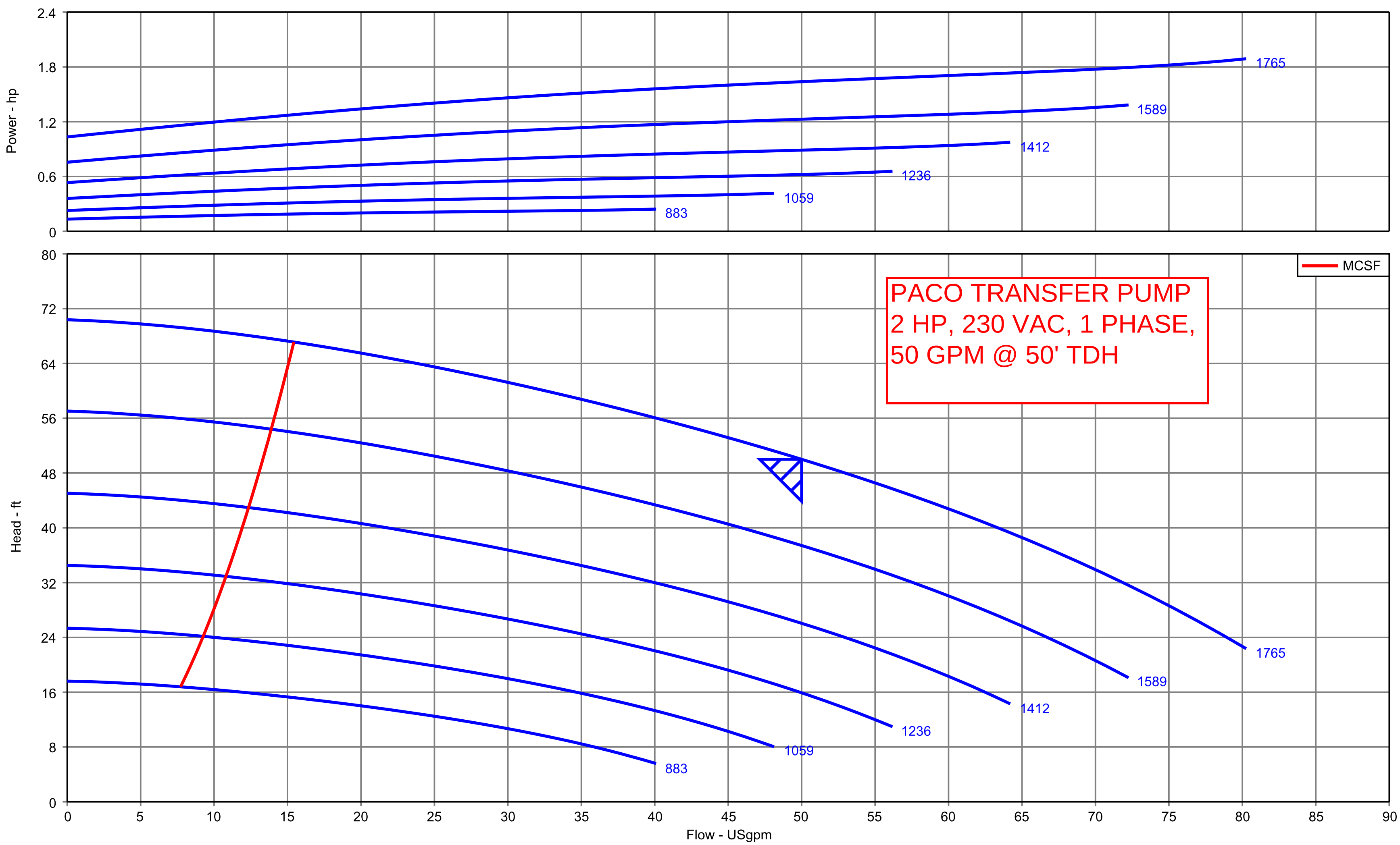
Specifications subject to change without notice.
Designed in the U.S.A.
Assembled in Taiwan.

MS-001272 v3.6

NOTES:

Appendix C-3
Mechanical Equipment

Multi-Speed Performance Curve



Project name / location	:	Tag Number	: 001	Speed, rated	: 1,765 rpm
Consulting engineer	:	Service	:	Flow, rated	: 50.00 USgpm
Customer	:	PACO Model	: 15951 LF	Differential head / pressure, rated	: 50.00 ft
Customer ref. / PO	:	Quantity	: 1	Fluid density, rated / max	: 1.000 / 1.000 SG
Quote number	: Kristjan041714	Quoted By (Sales Office)	: PFC Equipment Inc.	Viscosity	: 1.00 cP
Date last saved	: 04/17/2014 3:36 PM	Quoted By (Sales Engineer)	: Blake Elsen	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 0.99 / 1.00
	:	Stages	: 1	Based on curve number	: RC1949 Rev 1

Pump Performance Datasheet

Project name / location	:	Tag Number	: 001
Consulting engineer	:	Service	:
Customer	:	PACO Model	: 15951 LF
Customer ref. / PO	:	Quantity	: 1
Quote number	: Kristjan041714	Quoted By (Sales Office)	: PFC Equipment Inc.
Date last saved	: 04/17/2014 3:36 PM	Quoted By (Sales Engineer)	: Blake Elsen

Operating Conditions

Flow, rated	: 50.00 USgpm
Differential head / pressure, rated (requested)	: 50.00 ft
Differential head / pressure, rated (actual)	: 49.92 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 1,765 rpm
Impeller diameter, rated	: 8.52 in
Impeller diameter, maximum	: 9.60 in
Impeller diameter, minimum	: 7.00 in
Efficiency	: 38.53 %
NPSH required / margin required	: 4.44 / 0.00 ft
Ns (imp. eye flow) / Nss (imp. eye flow)	: 596 / 2,822 US Units
MCSF	: 15.43 USgpm
Head, maximum, rated diameter	: 70.38 ft
Head rise to shutoff	: 40.76 %
Flow, best eff. point (BEP)	: 53.42 USgpm
Flow ratio (rated / BEP)	: 93.59 %
Diameter ratio (rated / max)	: 88.75 %
Head ratio (rated dia / max dia)	: 67.16 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 0.99 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

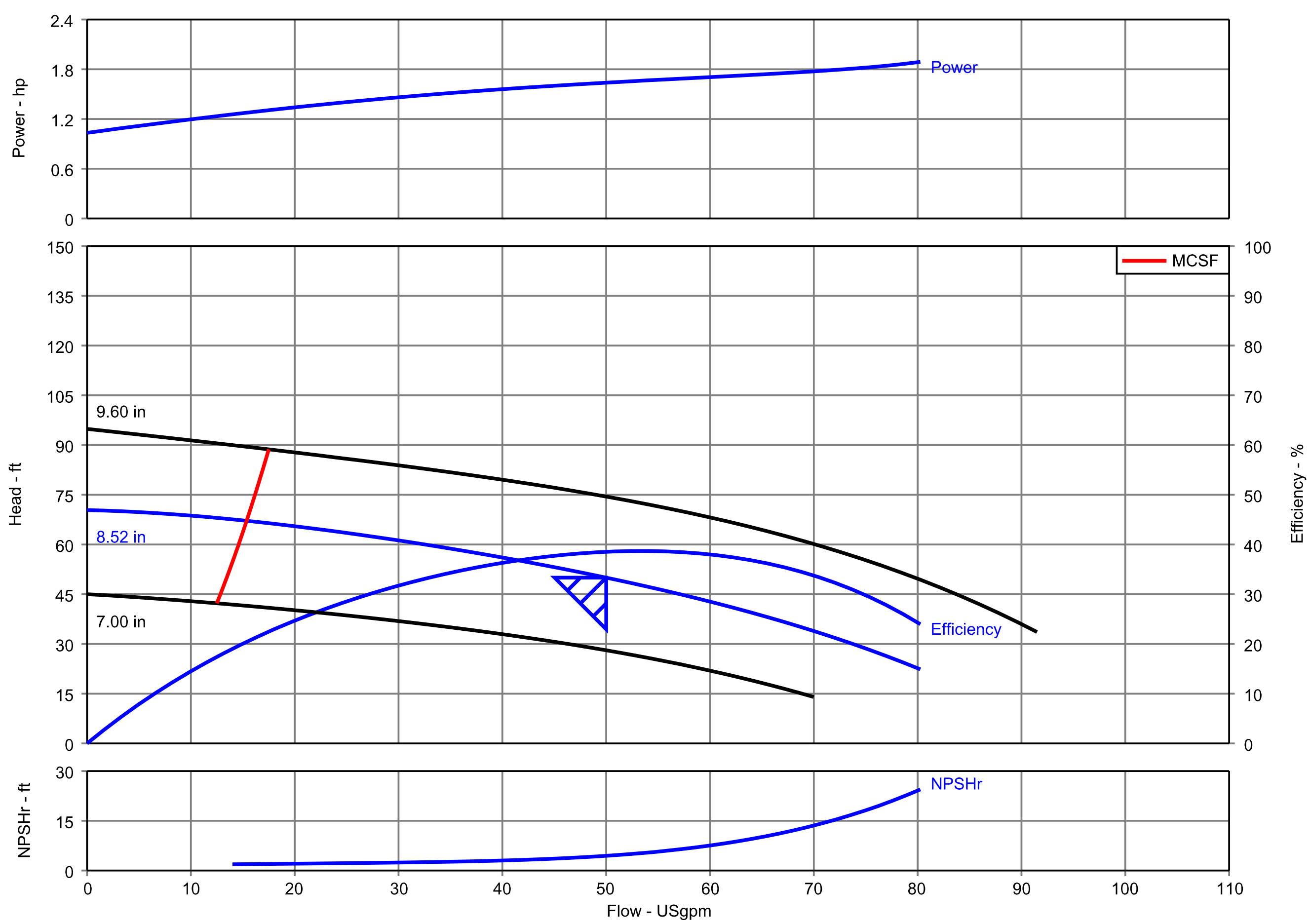
Material selected	: Cast iron

Pressure Data

Maximum working pressure	: 30.46 psi.g
Maximum allowable working pressure	: 175.0 psi.g
Maximum allowable suction pressure	: 175.0 psi.g
Hydrostatic test pressure	: 263.0 psi.g

Driver & Power Data

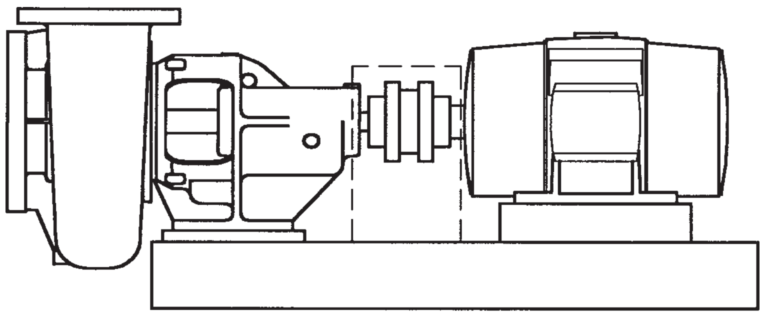
Motor sizing specification	: Based on duty point (rated power)
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 0.63 hp
Based on duty point (rated power)	: 1.64 hp
Non-overloading (max power)	: 1.89 hp
Nameplate motor rating	: 2.00 hp / 1.49 kW



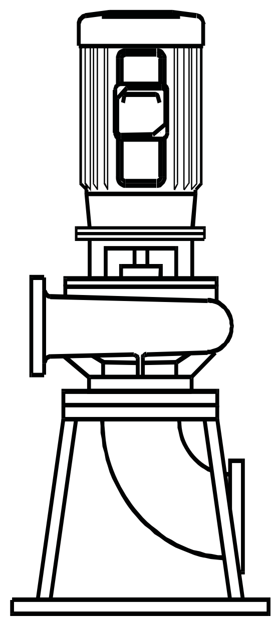
PACO
PUMPS

INSTALLATION, OPERATING & MAINTENANCE INSTRUCTIONS

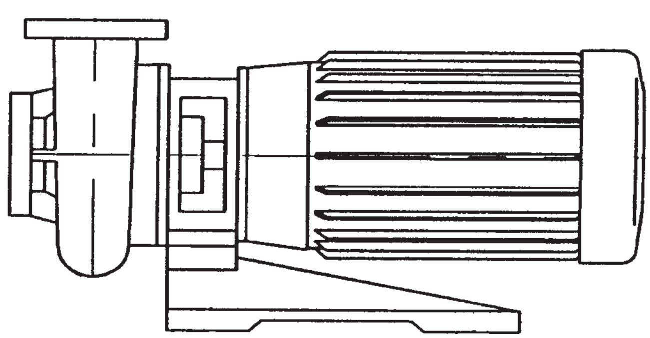
Type L End Suction Pumps



LF



LCV



LC

TABLE OF CONTENTS

CAUTIONS and WARNINGS are inserted at key points of this manual to provide check points for personnel and machinery safety. *CAUTIONS:* Apply to personnel. *WARNINGS:* Apply to personnel and machinery.

I. INSTALLATION-MECHANICAL

Read these instructions thoroughly before installing and operating your PACO Type L Centrifugal Pump. Successful operation depends on careful attention to the procedures described in Sections I, II, III and IV of this manual. Keep this instruction manual handy for future use.

A. PUMP IDENTIFICATION

- All PACO Pumps are identified by Catalog and Serial Numbers. These numbers are stamped on the pump nameplate (Fig.1 a) affixed to each pump volute casing, and should be referred to in all correspondence with the Company.

PACO PUMPS

CAT #: 10-20707-130101-1741

STOCK #:

SER #: 97R12345

GPM: 200 TDH: 80 ' IMP. DIA.: 5.0 "

BROOKSHIRE, TEXAS 34014412

FIGURE 1a

B. RECEIVING

- Check pumping unit for shortage and damage immediately upon arrival. Pump accessories when required are packaged in a separate container and shipped with the unit.

- If equipment is damaged in transit, promptly report this to the carrier's agent. Make complete notations on the freight bill to speed satisfactory adjustment by the carrier.

- Unload and handle the unit with a sling. **Do not lift unit by eye bolts on the motor!**

C. TEMPORARY STORAGE

- If pump is not to be installed and operated soon after arrival, store it in a clean, dry area of moderate ambient temperature.

- Rotate the shaft by hand periodically to coat bearing with lubricant to retard oxidation and corrosion.

- Follow motor manufacturer's storage recommendations where applicable.

D. LOCATION

- Locate the pump as close to the suction supply as possible. Use the shortest and most direct suction piping practical. Refer to paragraph H. SUCTION (INLET) PIPING.

- Locate the pump below system level wherever possible. This will facilitate priming, assure a steady liquid flow, and provide a positive suction head.

- Make sure sufficient NPSH (Net Positive Suction Head) is provided at the suction end by considering the pump's location in relation to the entire system. Available NPSH must always equal or exceed required NPSH specified on the pump performance curve.

- Always allow sufficient accessibility for maintenance and inspection. Provide a clear space with ample head room for use of a hoist strong enough to lift the unit.

- Make sure a suitable power source is available for the pump motor. Electrical characteristics should match those specified on the motor data plate, within the limits covered in Sections II and III.

- Avoid pump exposure to sub-zero temperatures to prevent pump liquid from freezing. If freezing conditions exist during shutdown periods, see Sections IIIE and IIIF for specific recommendations.

E. HORIZONTAL PUMP FOUNDATION

- Horizontal pumps should be permanently installed on a firm, concrete foundation mounting pad of sufficient size to dampen any vibration and prevent any deflection or misalignment. The pad may float on springs or be a raised part of the equipment room floor. The foundation should be poured without interruption to 3/4 to 1-1/2 inches below the final pump elevation. The top surface should be well scored or grooved before the concrete sets to provide a suitable bonding surface for the grout. Anchor bolts should be set in pipe sleeves for positioning allowance, as shown in (Fig. 2a) on page 4. Allow enough bolt length for grout, lower base plate flange, nuts and washers. Allow the foundation to cure several days before proceeding with pump installation.

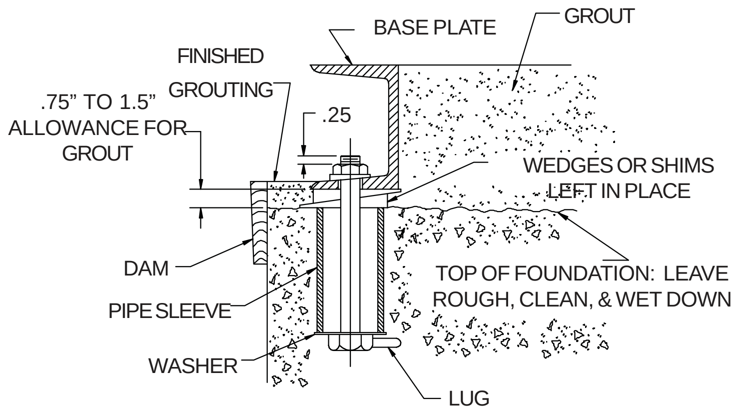


FIGURE 2a: Anchor Bolt Installation

F. SECURING THE BASE PLATE

- After the concrete pad has been poured and set, lower the pump base plate over the anchor bolts and rest it on loose adjustment wedges or shims placed near each anchor bolt and at intervals not to exceed 24” along each side.

  Shims or wedges must be placed to raise the bottom of the base 3/4” to 1-1/4” above the pad, allowing clearance for grout. Level the pump shaft, flanges, and base plate using a spirit level, adjusting the wedges or shims, as required.

- Check to make sure that the piping can be aligned to the pump flanges without placing any strain on either flange.

- After pump alignment has been established, put nuts on foundation bolts and tighten them just enough to keep the unit base plate from moving. Construct a form or dam around the concrete pad and pour grout in and around the pump base, as shown in (Fig. 2a). Grout compensates for uneven foundation, distributes the weight of the unit, and prevents shifting. Use an approved, nonshrinking grout (such as Embeco 636 by Master Builders, Cleveland, Ohio or equivalent). Allow at least 24 hours for this grout to set before proceeding with piping connections.

- After the grout has thoroughly hardened, check the foundation bolts and tighten if necessary. Recheck the pump alignment after the foundation bolts are secured.

G. VERTICAL MOUNTING INSTRUCTIONS

The PACO LCV Vertical Close Coupled pump need not be grouted to its foundation, but should be anchored with 4 anchor bolts set in concrete similar to the horizontal anchoring arrangement (Fig. 2a).

H. PIPING-GENERAL

- **Do not use pump as a support for piping!** Use pipe hangers or other supports at proper intervals to provide complete piping support near the pump.

- Both suction and discharge piping should be independently supported and properly aligned so that no strain is transmitted to the pump when flange bolts are tightened.

- Make sure piping is as straight as possible, avoiding unnecessary bends and fittings. Where necessary, use 45° or long-sweep 90° pipe fittings to decrease friction loss.

- Where flanged joints are used, make sure that inside diameters properly match and mounting holes are aligned.

- **Do not spring or force piping when making any connections!**

I. SUCTION (INLET) PIPING

The sizing and installation of suction piping is particularly important. It must be selected and installed in a manner that minimizes pressure loss and permits sufficient liquid flow into the pump during starting and operation. Many NPSH problems can be traced directly to improper design of suction piping systems. Observe the following precautions when installing suction piping:

- Suction piping should be as direct as possible, and ideally the length should be at least ten times the pipe diameter. Short suction piping can be the same diameter as the suction opening. Longer piping should be one or two sizes larger (depending on length), reducing to the diameter of the pump suction opening.

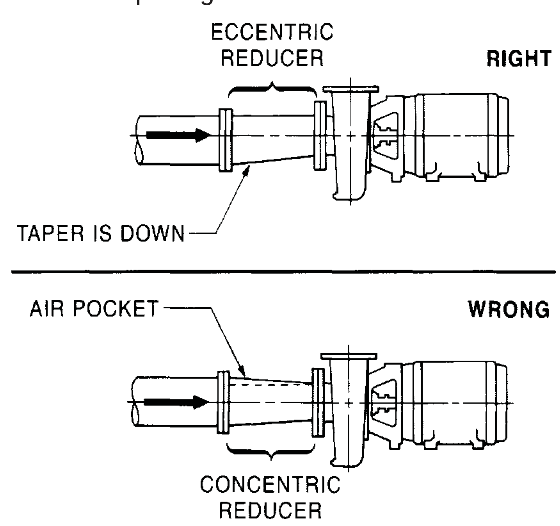


FIGURE 3a

- Use an eccentric reducer, with the eccentric side down (Fig. 3a) when reducing the pipe diameter to the diameter of suction opening.

- **At no point should suction piping be smaller in diameter than the pump suction opening.**

- Horizontal suction lines should follow an even gradient, if possible. A gradual upward slope to the pump is recommended for suction lift conditions, and a gradual downward slope for positive suction head.

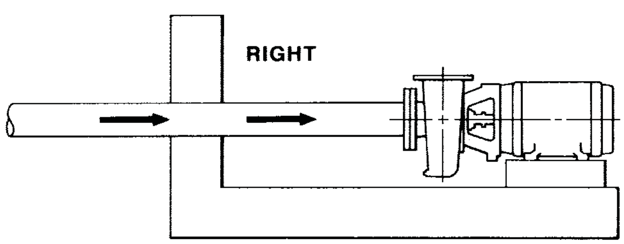
- Avoid any high points, such as pipe loops (Fig. 4a), that may create air pockets and throttle the system or produce erratic pumping.

- Install a valve in the suction line to isolate the pump during shutdown and maintenance, and facilitate pump removal. Where two or more pumps are connected to the same suction line, install duplicate gate valves to isolate each pump from the line.

- Gate valves should always be installed in positions that avoid air pockets. Globe valves should not be used, particularly when NPSH is critical.

- During pumping operation, valves on suction line must always be at **FULL OPEN**.

- Properly sized pressure gauges can be installed in gauge taps on pump suction and discharge nozzles. Gauges enable the operator to monitor pump performance and determine that the pump conforms to the parameters of the performance curve. If cavitation, vapor binding, or other unstable operation occurs, pressure gauges will indicate wide fluctuation in suction and discharge pressures.



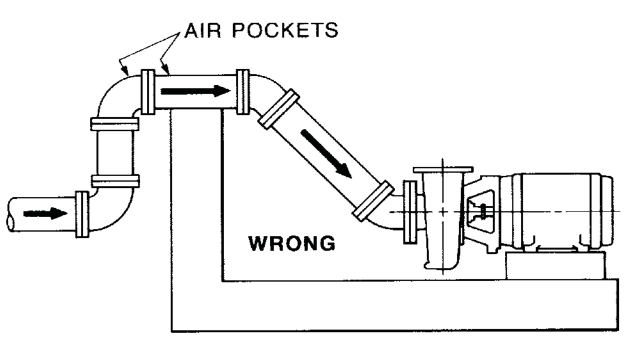


FIGURE 4a

J. DISCHARGE (OUTLET) PIPING

- Short discharge piping can be the same diameter as the pump discharge opening. Longer piping should be one or two sizes larger depending on length.

- An even gradient is best for long horizontal runs of discharge piping.

- Install a valve near the discharge opening to prime and start the pump. The discharge gate valve is also used to isolate the pump during shutdown, maintenance, and facilitate pump removal.

- Any high points in discharge piping may entrap air or gas and thus retard pump operation.

- If the possibility of liquid hammer exists, (i.e. check valves are used) close the discharge gate valve before pump shutdown.

K. SHAFT SEALING-GENERAL COMMENTS

- PACOoffers both mechanical seals and packed stuffing boxes as a means to seal the shaft. Pumps with stuffing boxes are normally packed before shipment. If the pump is installed within 60 days after shipment, the packing material will be in good condition for operation with a sufficient supply of lubrication. If the pump is stored for a longer period, it may be necessary to repack the stuffing boxes.

- The stuffing box must be supplied at all times with a source of clean, clear liquid to flush and lubricate the packing. When pumps are equipped with mechanical seals, no maintenance or adjustment is required. Mechanical seals are preferred to packing on most applications because they require less maintenance.

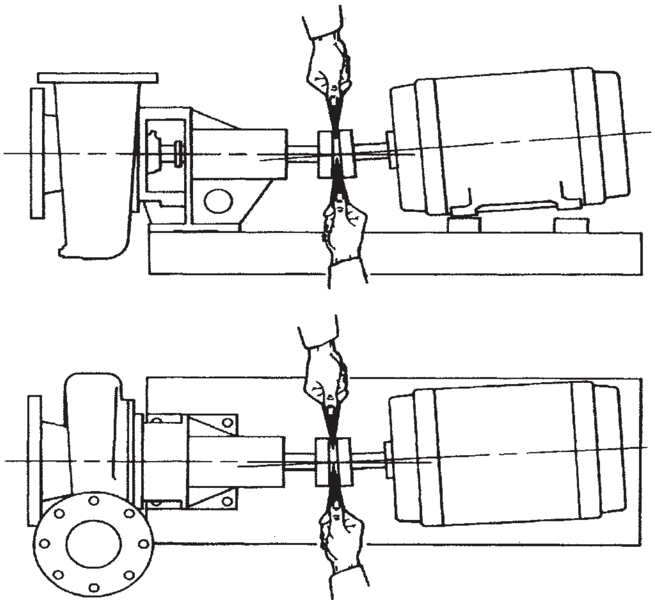
L. PACKING GLAND ADJUSTMENT

- With the pump running, the packing gland should be adjusted to permit 40 to 60 drops per minute leakage. This is required for shaft lubrication. After initial start up, additional packing and adjustment may be required. Pumps with mechanical seals require no adjustment.

M. MECHANICAL SEALS

All PACO Type L pumps that are equipped with mechanical seals are matched to conditions for which the pump was sold. Observe the following precautions to avoid seal damage and obtain maximum seal life:

CHECKING ANGULAR ALIGNMENT



CHECKING PARALLEL ALIGNMENT

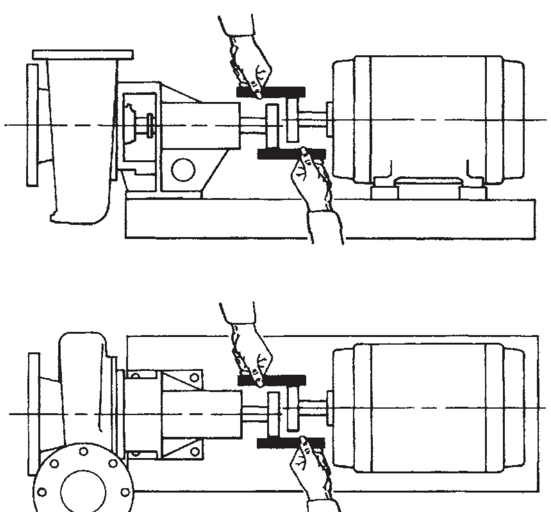


FIGURE 5a: Checking Alignment

- Do not exceed temperature or pressure limitations for the mechanical seal used.

- DO NOT RUN THE PUMP DRY OR AGAINST A CLOSED VALVE! Dry operation will cause seal failure within minutes.

- Clean and purge suction piping in new installations before installing and operating pump. Pipe scale, welding slag and other abrasives can cause rapid seal failure.

N. COUPLING ALIGNMENT

- The following anchoring and alignment procedure is typical and, if performed with care, should result in a smooth running, trouble-free installation.

- If the pump and motor were shipped mounted on the pump base as an assembly, remove the coupling guard.

- The pump and motor were accurately aligned at the factory, but handling during shipment usually alters this pre-alignment . Using a small straight edge and feeler gauges or a dial indicator, check for horizontal, vertical, and angular misalignment of the coupling hubs (Fig. 5a).

- Coupling alignment is proper when the dial indicator reads no more than .005” run out in any direction (or when the straight edge contacts both hubs evenly in both horizontal and vertical positions). If misalignment is detected, loosen the motor and shift or shim as necessary to re-align, then re-tighten bolts. **Always align the motor to the pump as piping strain will occur if the pump is shifted. *Never reposition pump on base!***

- After final piping connections to the pump have been made, motor wiring compared, correct rotation has been established, and piping filled with liquid, check shaft alignment once again.

- Leave the coupling guards off until the pump priming procedure is completed for a final shaft alignment check.

- To protect personnel from rotating machinery, **Always install coupling guards after installation is complete; before starting pump!**

II. INSTALLATION—ELECTRICAL

A. MOTORS, GENERAL

The motor control circuit must have the following components in order to comply with the National Electrical Code.

- Motor Disconnecting Device: A motor disconnecting device must be installed that is capable of disconnecting both the controller (motor starter) and the motor from their source of power.

  The disconnecting device must be located so that the controller (motor starter) can be seen from the disconnecting means. In all cases, the distance from the disconnecting device to the controller must be less than 50'.

  In most installations the disconnecting device will be a circuit breaker or fusible disconnect switch.

- Motor short circuit and ground fault protection:

  Short circuit and ground fault protection are usually provided by means of a circuit breaker or fusible disconnect switch.

  The selection of the size of the circuit breaker or fuse must be in accordance with Section 430-52 and Table 430-152 of the National Electrical Code.

- Motor controller with running over current protection (magnetic starter):

  These components must be installed in accordance with applicable local and state electrical codes in addition to the National Electrical Code.

B. INSTALLATION WIRING

- Mount the control panel or motor starter(s) in close proximity to the pump to provide convenient control and ease of installation.

- Wire panel or starter(s) to motor(s) and pilot device(s): Wires to each motor must be sized for at least 125% of the motor nameplate full load amps. AWG #16 Type THW stranded wire is recommended for wiring of pilot devices (float switches).

- Check incoming power source to ensure that it is the same as the voltage and phase of the motors.

- Verify that the starters are suitable to operate the pump motors on voltage and phase that is available.

III. OPERATION

A. PRIMING

- The PACO Type L pump is not self-priming, and must be completely primed (filled with liquid) before starting.

- If the pump will operate with a positive suction head, prime by opening the suction valve and allowing liquid to enter pump casing. Open air vents at this time, and make sure all air is forced from pump by liquid before closing.

- Rotate the shaft by hand to free entrapped air from impeller passageways.

- If pump has a suction lift, priming must be accomplished by other methods. The use of foot valves or ejectors, or manual filling of the pump casing and suction line with liquid are possible methods suggested for this purpose.

- **CAUTION: Never run the pump dry in the hope that it will prime itself!** Serious damage to the mechanical seal will result.

B. PRE-START CHECKLIST

WARNING: In the interest of operator safety, the unit must not be operated above the nameplate conditions. Such operation could result in unit failure causing injury to operating personnel. Consult instruction book for proper operation and maintenance of the pump and its supporting components.

Make the following inspections before starting your Sulzer Type L pump:

- ☐ Make sure all wiring connections to the motor (and starting device) match the wiring diagram and produce clockwise rotation as viewed from the back of the motor.

- ☐ If the motor has been in storage for an extended length of time, either before or after installation, refer to motor instructions before starting.

- ☐ Check voltage, phase, and line circuit frequency with the motor data plate.

- ☐ Turn rotating element by hand to make sure it rotates freely.

- ☐ Tighten plugs in gauge and drain taps. If pump is fitted with pressure gauges, keep gauge cocks closed when not in use.

- ☐ Check suction and discharge piping for leaks, and make sure all flange bolts are securely tightened.

C. MOTOR ROTATION

CAUTION: Never check driver rotation unless pump and driver couplings are disconnected and physically separated. Failure to follow this instruction can result in serious damage to pump and driver if rotation is wrong.

After the unit has been wired and checked to insure that all components in the system (disconnect device, magnetic starters, pilot devices and motors) are properly connected, check motor rotation as follows:

- For 3 phase units only—momentarily energize the motors to ensure that the rotation is correct as indicated by the arrow cast into the pump volute. If rotation is incorrect, interchange two wires at the motor starter terminals T1 and T2.

- **IMPORTANT:** The pumps must not be operated while dry. Use extreme caution that motors are energized only momentarily to determine proper rotation.

D. STARTING THE PUMP

WARNING: The pump must not be operated without an approved coupling guard in place. Failure to observe this warning could result in injury to operating personnel.

- Install coupling guard on flexible coupled units.

- Fully open gate valve (if any) in suction line, and close gate valve in discharge line.

- Fill suction line with liquid and completely prime pump.

- Start the motor (pump).

- Immediately make a visual check of pump and suction piping for pressure leaks.

- Immediately after pump reaches full operating speed, slowly open the discharge gate valve until complete system flow is achieved.

- Check discharge piping for pressure leaks.

- If pump is fitted with pressure gauges, open gauge cocks and record pressure reading for future reference. Verify that the pump is performing in accordance with parameters specified on performance curve.

- Check and record voltage, amperage per phase, and kilowatts, if a wattmeter is available.

E. VOLTAGE REGULATION

The motor will operate satisfactorily under the following conditions for voltage and frequency variation, but not necessarily in accordance with the standards established for operation under rated conditions:

- The voltage variation may not exceed 10% above or below rating specified on the motor data plate.

- The frequency variation may not exceed 5% above or below motor rating.

- The sum of the voltage and frequency variations may not exceed 10% above or below motor rating, provided the frequency variation does not exceed 5%.

F. PUMP SHUTDOWN

The following shutdown procedures will apply in most normal shutdowns for the PACO Type L pump. If pump will be inoperative for an extended length of time, follow storage procedures in Section IC.

- Always close the discharge gate valve before stopping pump. Close valve slowly to prevent hydraulic shock.

- Cut power to motor.

G. SHORT DURATION SHUTDOWN

- For overnight or temporary shutdown periods under nonfreezing conditions, the pump may remain filled with liquid. Make sure the pump is fully primed before restarting.

- For short or frequent shutdown periods under freezing conditions, keep fluid moving within pump casing and insulate or heat pump exterior to prevent freezing.

H. EXTENDED PERIOD SHUTDOWN

- For long shutdown periods, or to isolate the pump for maintenance, close suction gate valve. If no suction valve is used and the pump has positive suction head, drain all liquid from suction line to terminate liquid flow into pump suction nozzle. Remove plugs in pump drain and vent taps, as required, and drain all liquid from the pump volute casing.

- If freezing conditions will exist during long shutdown periods, completely drain the pump and blow out all liquid passages and pockets with compressed air. Freezing of pump liquid can also be prevented by filling the pump with antifreeze solution.

IV. MAINTENANCE

WARNING: Do not attempt any maintenance, inspection, repair or cleaning in the vicinity of rotating equipment. Such action could result in personal injury to operating personnel.

Before attempting any inspection or repair on the pump, the driver controls must be in the "OFF" position, locked and tagged to prevent injury to personnel performing service on the pump.

A. MOTOR LUBRICATION

- To lubricate the motor while running or at rest, remove grease drain plug (if any) and filler plug on grease fitting. Grease with clean lubricant until grease appears at drain hole or along motor shaft.

MOTOR RPM	MOTOR HP	OPERATING CONDITIONS		
		STANDARD	SEVERE	EXTREME
1750 & BELOW	1/3-7-1/2	3 YRS.	1 YR.	6 MOS.
	10-40	1-3 YRS.	6MOS.-1 YR.	3 MOS.
	50-150	1 YR.	6 MOS.	3 MOS.
	200 & UP	1 YR.	6 MOS.	3 MOS.
ABOVE 1750	(ALL HP)	6 MOS.	3 MOS.	3 MOS.

STANDARD CONDITIONS:
8 Hours per day operation, normal or light loading, clean air, 100ºF, maximum ambient temperature.

SEVERE CONDITIONS:
Continuous 24-hour operation, shock loading or vibration, poor ventilation, 100º-150ºF, ambient temperature.

EXTREME CONDITIONS:
Continuous operation, heavy shock or vibration, dirt or dust in air, extreme ambient temperature.

TABLE 6a: Recommended Lubrication Periods.

One-half to one cubic inch of grease is sufficient for motors 5 HP and under, with proportionately more grease for greater HP motors.

- Most fractional and some integral frame motors have “sealed-for-life” bearings, and do not require further lubrication throughout motor life.
- Always follow motor manufacturer’s lubrication instructions, and periodically check grease fittings and drain plugs for leaks.
- If lubricating instructions do not accompany motor, refer to Table 6a for recommended lubrication periods.
- Table 7a lists recommended types of grease for both pump and motor lubrication. These types have all been thoroughly tested and should be used whenever possible.

B. PUMP LUBRICATION

- PACO Type LF pumps on horizontal bearing frames have bearing that may be sealed for life (requiring no lubrication), regreasable or oil lubricated.

MANUFACTURER	LUBRICANT
SHELL	DOLIUM® R™
EXXON	POLYREX®
CHEVRON	SRI GREASE NLGI 2
	BLACK PEARL - NLGI 2
PHILIPS	POLYTAC™
TEXACO	POLYSTAR RB

TABLE 7a

- To lubricate regreasable bearings, remove grease drain plug (if any) and filler plug. Add clean ball bearing lubricant until grease appears at drain hole or along shaft. On units with drain hole, all old grease can be purged out ahead of new. In such cases, the drain should be left unplugged for several minutes during pump operation to allow excess grease to be forced out.
- Lubricate bearing frame bearings at intervals of one to three months, depending on severity of environment. Pumps in a clean, dry, moderate temperature (100° F maximum) environment should be regreased at three month intervals. Too much grease can cause premature bearing failure—do not over-grease.

3. On those PACO Type LF Centrifugal End Suction pumps ordered with oil lubricated bearings, (Fig. 8a) a regular oil maintenance program must be enforced. Pumps with oil lubricated bearings are fitted with a transparent reservoir (constant level oiler) that maintains oil level about the centerline of the bearing. When necessary, the oil supply in the reservoir of the constant level oiler must be renewed.

- After the first 200 hours of operation the oil should be changed. To change the oil, remove the drain plug at the bottom of the bearing cover and the filler plug (that also acts as a vent plug) at the top of the housing. After draining oil, replace the fittings and refill with an acceptable oil selected from Table 9a. After the first oil change, the oil should be changed again at 2000 hours and then at intervals of 8000 hours or once yearly, thereafter.

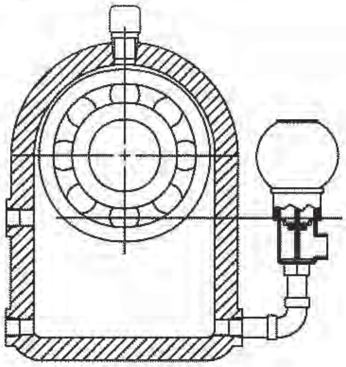


FIGURE 8a

LUBRICANT MANUFACTURER	BEARING OIL BRAND NAME
Aral Refining Co.	ARAL OIL CMU ARAL OIL TU 518
British Petroleum Co.	BP ENERGOL TH 100-HB
Calypsol Oil Company	CALYPSOL BISON OIL SR 25 or SR 36
Standard Oil Company	CHEVRON HYDRAULIC OIL 11 CIRCULATING OIL 45
Esso Corporation	ESSO-MAR 25 TERESSO 47 ESSTIC 50
Fina Oil Company	FINA HYDRAN 34 FINA CIRKAN 32
Gulf Refining Company	GULF HARMONY 47 GULF PARAMOUNT 45
Socony Mobil Oil Co.	VAC HLP 25 MOBILUX D.T.E. 25
Shell Oil Company	SHELL Tellus OIL 29
Sundco Oil Company	SUNVIS 821
The Texas Company	TEXACO Ursa Oil P 20 DEA VISCOBIL Sera 4
Wisura Refining Company	WISURA Norma 25 (36) WISURA Tempo 25 (36)

TABLE 9a: List of Acceptable Lube Oils

C. DISASSEMBLY OF PUMPS

(Refer to drawing on page 11).

- Complete disassembly instructions are outlined below. Proceed only as far as required to perform the maintenance work needed.
- Turn off power.
- Drain system. Flush, if necessary.
- Closed coupled units: Remove motor hold down bolts.

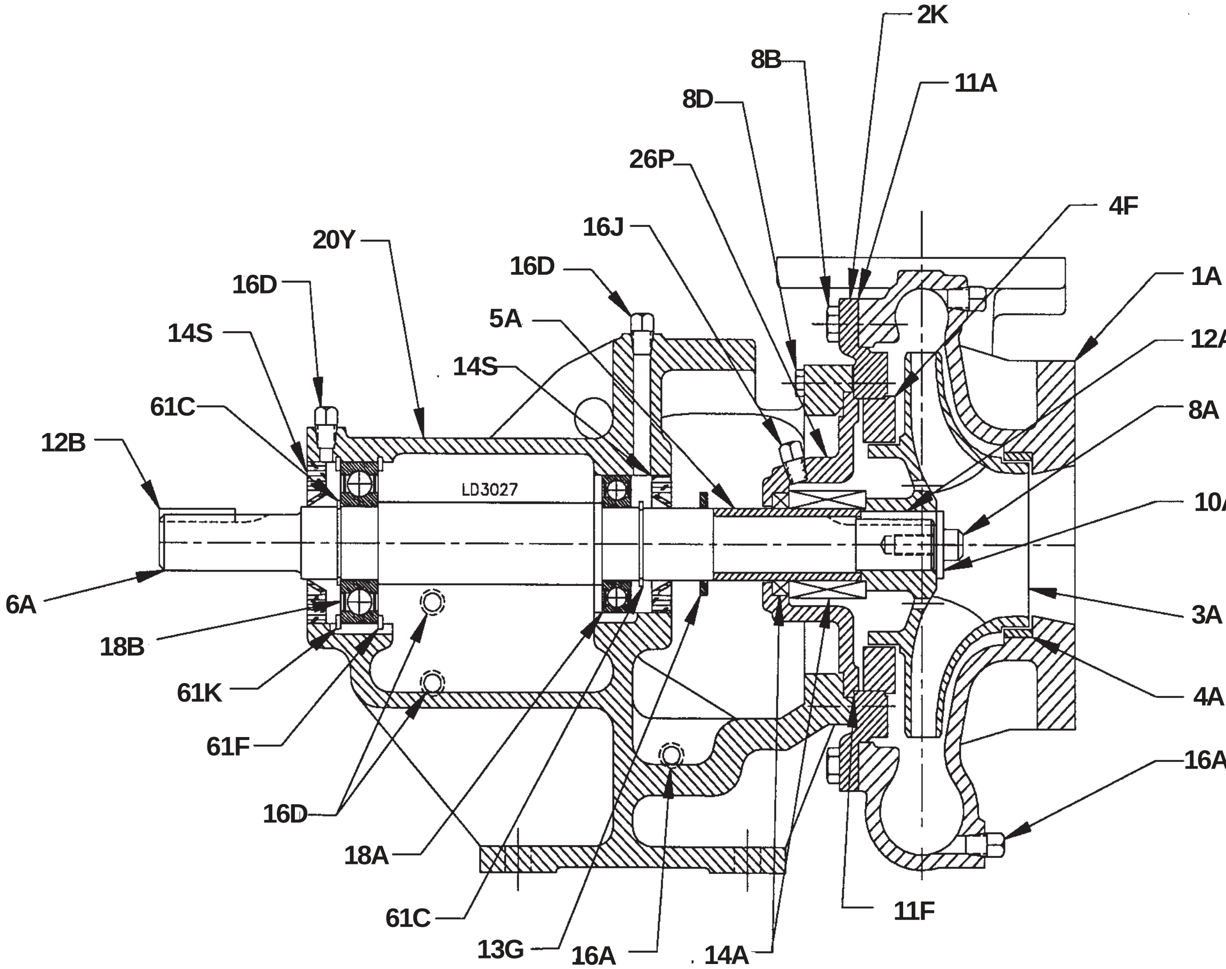
DISASSEMBLY OF LIQUID END.

- Remove casing bolts (8B)
- Remove back pull-out bearing frame assembly (20Y) from casing (1A)
- Unscrew impeller nut (8A)
- **CAUTION: Do not insert screwdriver between impeller vanes to prevent rotation.** It may be necessary to use a strap wrench around the impeller or shaft to prevent rotation.
- Use appropriate size gear puller aligned behind impeller vanes to remove impeller (3A) from shaft (6A).
- Remove impeller key (12A).
- Remove backplate bolts (8D). Remove backplate (2K) and seal housing (26P).
- Place seal housing on flat surface and press out seal seat (14A).
- If shaft sleeve (5A) requires replacement, it must be evenly heated to approximately 350°F to loosen locktite. Twist sleeve off shaft (6A).

DISASSEMBLY OF BEARING FRAME.

- Remove slinger (13G).
- Remove grease seal(s), (14S) if any.
- Remove bearing house retaining ring (61K).
- Press or tap on the pump end of the bearing-shaft assembly until one bearing is out.
- When one bearing is out, remove second retaining ring (61F), then remove complete assembly from bearing housing.
- Remove shaft retaining ring (61C) and press off bearings.
- Press on new bearings. Remember to press only on inner race of bearing while pressing them on.
- Assemble frame in the reverse procedure used for disassembly.
- Observe the following when reassembling the bearing frame.

TYPE LF, CROSS SECTION AND PARTS LIST



ITEM NO	PART NAME	ITEM NO	PART NAME	ITEM NO	PART NAME
1A	Casing	*10A	Washer, Packing	16L	Plug, Seal Chamber
2K	Backplate	10A	Washer, Impeller	18A	Bearing, Inboard
3A	Enclosed Impeller	11A	Gasket, Casing	18B	Bearing, Outboard
4A	Case Wear Ring	11F	Gasket, Backplate	20Y	Bearing Frame
**4F	Balance Ring	12A	Key, Impeller	*22A	Stud, Packing Gland
5A	Shaft Sleeve	12B	Key, Coupling	26P	Seal Housing
*5L	Lantern Ring	*13A	Packing	*26U	Packing Box
6A	Shaft	13G	Slinger	*35F	Nut, Packing Gland
*7A	Packing Gland	14A	Shaft Seal	61C	Snap Ring
8A	Cap Screw, Impeller	14S	Lip Seal	*61J	Snap Ring
8B	Cap Screw, Casing	16A	Plug, Drain	*Packed Pumps Only	
8D	Cap Screw, Brg. Frame	16D	Plug, Grease/Oil Filter	**If Applicable	

PACO PUMPS

- Replace lip seals (14S) if worn or damaged.

- Replace bearings (18A), (18B) if loose, rough or noisy when rotated.

- Check shaft (6A) for runout at the sleeve (5A) area. Maximum permissible is .002” T.I.R.

D. REASSEMBLY OF PUMPS

- All parts should be cleaned before reassembly.

- Refer to parts list to identify required replacement items. Specify pump serial or catalog number when ordering parts.

- Reassembly is the reverse of disassembly.

- Observe the following when reassembling the liquid end:

- All mechanical seal components must be in good condition or leakage may result. Replacement of complete seal assembly is recommended.

- New shaft sleeves are installed by bonding to shaft with hydraulic setting locktite.

V. ORDERING PARTS

- **PACO Pumps** has over 175 years of experience in the design, manufacture, and application of centrifugal pumps and pumping systems. PACO's commitment to state-of-the-art pump design and quality manufacturing assures maximum user benefits with optimum equipment life at lower cost.

- PACO’s commitment to their customers continues through an extensive service organization. Highly trained technicians can assist customers with initial startup, troubleshooting, repair, and system analysis.

PACO maintains an extensive stock of replacement parts and parts kits for our most popular model pumps. Shipment of these parts is normally made within three days after receipt of an order. On larger pumps, where it is impractical for our factory to inventory low usage parts, replacement parts are normally manufactured and shipped within 15 working days of receipt of an order. In order to reduce pump repair time and shorten inconvenient pump service interruptions, it is suggested that the pump user stock spare parts. For suggested spare parts see Replacement Parts Guide A1b.2, attached, and contact your local PACO Sales Representative (see back cover for the number of your nearest PACO Sales office). Since spare parts requirements and quantities vary for specific pump constructions, allow your PACO Representative to help in defining your spare part requirements. To ensure that the proper replacement parts are ordered for your particular pump model, when you call:

- Identify all pertinent data from the pump name plate (see Pump Identification). This should always include the pump Catalog or Model Number, and the pump Serial Number.

- For replacement impellers, also include from the nameplate the operating conditions (GPM and TDH) and the impeller diameter.

- Identify all parts by item number and description as indicated by the appropriate assembly drawing in this manual, for your particular pump model.

VI. TROUBLE SHOOTING

A.

SYMPTOMS	CAUSE CODE
Pump does not deliver any liquid at start-up.	1*2*3*4*5*6*7*8*9*10*11*14*16*17*22*23*24*34
Pump stops delivering liquid after start-up.	2*3*4*5*6*7*8*9*10*11*12*13*22*23*24*34
Pump overheats and/or ceases to deliver liquid.	1*3*9*10*11*21*22*27*29*30*31*33*34*40*41
Insufficient flow rate.	2*3*4*5*6*7*8*9*10*11*14*16*17*20*21*22*23*24*25*26*34
Excessive flow rate.	15*18*20*34
Discharge pressure is too high.	4*14*16*18*20*22*23*24*25*26*34
Shaft seal leaks appreciably, or the packing leaks excessively.	27*28*29*30*33*34*35*36*39*41
Shaft seal or packing fails prematurely.	12*13*27*28*29*30*33*34*35*36*37*38*39*41
Pump uses too much power.	15*16*18*19*20*23*25*27*28*31*33*34*35*37*38*44
Pump runs rough and noisily.	2*3*4*5*6*7*8*9*10*11*15*17*18*21*23*24*27*28*29*30*31*32*33*34*40*41*42*45*46*
Bearings overheat and/or fail prematurely.	27*28*29*30*31*32*33*34*40*41*42*43*44*45*46

B. POSSIBLE CAUSES

1. The pump has not been properly bled of air.
2. The pump suction line have not been completely primed.
3. The suction head (NPSHR) required by the pump is too high, or the net positive suction head available (NPSHA) at your facility is too low.
4. The fluid pumped contains too much entrained air or gas.
5. There are air pockets in the suction line.
6. An entry of air has suddenly occurred in the suction line.
7. An entry of air past the shaft seal into the pump has occurred.
8. The inlet of the suction line is insufficiently submerged.
9. The suction valve is closed or only partially open.
10. The suction strainer is clogged with dirt or debris.
11. The foot valve is clogged or undersized.
12. Little or no cooling fluid supplied to the shaft seals.
13. The lantern ring is not positioned opposite the flushing inlet thereby restricting fluid flow.
14. Pump drive rotational speed too low.
15. Pump drive rotational speed too high.
16. Pump rotation wrong or impeller installed backwards.
17. Total head of installation (back Pressure) higher than rated total head of the pump.
18. Total head of installation (back Pressure) lower than rated total head of the pump.
19. Density of fluid pumped differs from that specified when the pump was purchased.
20. Viscosity of fluid pumped differs from that specified when the pump was purchased.
21. The pump is operating at too low a rate of flow (The discharge valve may be throttled too much).
22. If pumps are operating in parallel, the pump characteristics may not be suitable for parallel operation.
23. The impeller may be clogged with debris.
24. The impeller may be damaged.
25. The casing and impeller wear rings may be excessively worn.

TROUBLE SHOOTING-POSSIBLE CAUSES (Cont'd)

26. There may be internal leakage from the discharge to the suction compartments as the result of internal gasket failure.

27. There may be a misalignment of the pump shaft.

28. The shaft may chatter because it is bent.

29. The pump may run rough due to improper balancing of the impeller.

30. The shaft may not be running due to worn bearings.

31. The impeller may be rubbing against the inside of the case.

32. The concrete pad might not be of sufficient size to provide pump stability.

33. The pump may have become misaligned during installation.

34. The operating conditions of the installation do not agree with the data specified when the pump was purchased.

35. The shaft seal may be incorrectly installed, or the stuffing box has not been packed correctly.

36. The shaft sleeve may be scored or pitted in the region of the packing due to dirt or abrasive matter in the flushing fluid.

37. Excessive tightening of the packing gland may block the flushing port thereby diminishing the sealing fluid flow.

38. Packing material may have become wedged or extruded between the shaft and the bottom of the stuffing housing due to excessive clearance on the packing backup washer.

39. The mechanical seal may have been damaged by running dry.

40. There may be excessive axial thrust (side loading) due to improper impeller central alignment.

41. The bearings may be worn.

42. The bearings may have been damaged during installation and/or dirt or other foreign matter may have entered the bearings during greasing or oiling.

43. Excessive greasing may cause the bearings to overheat.

44. Inadequate lubrication may be causing bearing failure.

45. Dirt may have entered the bearings past the O-Rings.

46. Moisture may have entered the bearing housing causing the bearings to rust.

PACO
PUMPS

Terms And Conditions Of Sale

SECTION 1: THE CONTRACT

The Contract shall be comprised of the following terms, together with such terms and conditions as are set forth in Seller's written proposal or quotation (the "Quotation"), including any documents, drawings or specifications incorporated therein by reference, and any additional or different terms proposed in Buyer's purchase order (the "Purchase Order") that are accepted by Seller in writing, which together shall constitute the entire agreement between the parties, provided, however, that preprinted terms on Buyer's purchase order or invoice shall not apply and Seller gives notice of objection to such terms. An offer by Seller in its Quotation that does not stipulate an acceptance date is not binding. This Contract shall be deemed to have been entered into upon written acknowledgment of the Purchase Order by an officer or authorized representative of Seller, which may not be modified, supplemented, or waived except in a writing executed by an authorized representative of the party to be bound.

SECTION 2: PRICE

The price quoted in the Quotation shall be the Purchase Price unless otherwise agreed in the Purchase Order. The Purchase Price for equipment shall include packing for shipment. Field Services shall be provided at Seller's standard rates. All other costs, including packing for storage, freight, insurance, taxes, customs duties and import/export fees, or any other item not specified in the Contract, shall be paid by Buyer unless separately stated in the Quotation and included in the price quoted. Any sales, use, or other taxes and duties imposed on the transaction or the equipment supplied shall be paid or reimbursed by Buyer.

SECTION 3: PAYMENT TERMS

Payment shall be due within 30 days of the date of Seller's invoice in U.S. funds unless otherwise agreed. If Buyer does not observe the agreed dates of payment, Buyer shall pay interest to Seller on overdue amounts at a rate that is the higher of: 9% per annum or a rate 5% in excess of the rate borne from time to time by new issues of six-month United States Treasury bills. Seller shall be entitled to issue its invoice for the Purchase Price for equipment upon the earlier of shipment, or notice to Buyer that Seller is ready to ship, and for services, upon completion. If the Purchase Price exceeds $250,000 USD, Buyer shall pay the Purchase Price in Progress payments as follows: Fifteen percent (15%) upon submittal of general arrangement drawings, thirty five percent (35%) after receipt of first Bowl Casting, twenty percent (20%) after first case/bowl hydro test or bowl machining and thirty percent (30%) after notification of ready to ship.

SECTION 4: ACCEPTANCE AND INSPECTION

All equipment shall be finally inspected and accepted by Buyer within 14 days after delivery or such other period of time as is agreed in the Purchase Order. Buyer shall make all claims (including claims for shortages), excepting only those provided for under the warranty clause contained herein, in writing within such 14 day period or they are waived. Services shall be accepted upon completion. Buyer shall not revoke its acceptance. Buyer may reject the equipment only for defects that substantially impair its value, and Buyer's remedy for lesser defects shall be in accordance with Section 10, Warranty. If tests are made by Buyer to demonstrate the ability of the equipment to operate under the contract conditions and to fulfill the warranties in Section 10, Buyer is to make all preparations and incur all expenses incidental to such tests. Seller will have the right of representation at such tests at its expense, and the right to technically direct the operation of the equipment during such tests, including requiring a preliminary run for adjustments.

SECTION 5: TITLE AND RISK OF LOSS

Full risk of loss (including transportation delays and losses) shall pass to Buyer upon delivery, regardless of whether title has passed to Buyer, transport is arranged or supervised by Seller, or start-up is carried out under the direction or supervision of Seller. Delivery shall be ex works, INCOTERMS 2000. Loss or destruction of the equipment or injury or damage to the equipment that occurs while the risk of such loss or damage is borne by Buyer does not relieve Buyer of its obligation to pay Seller for the equipment.

SECTION 6: PATENT OR TRADEMARK INFORMATION

If the equipment sold hereunder is to be prepared or manufactured according to Buyer's specifications, Buyer shall indemnify Seller and hold it harmless from any claims or liability for patent or trademark infringement on account of the sale of such goods.

SECTION 7: CHANGES

Buyer may request, in writing, changes in the design, drawings, specifications, shipping instructions, and shipment schedules of the equipment. As promptly as practicable after receipt of such request, Seller will advise Buyer what amendments to the Contract, if any, may be necessitated by such requested changes, including but not limited to amendment of the Purchase Price, specifications, shipment schedule, or date of delivery. Any changes agreed upon by the parties shall be evidenced by a Change Order signed by both parties.

SECTION 8: CANCELLATION OR TERMINATION

Buyer shall have the right to cancel the Contract upon 15 days' prior written notice to Seller, and Seller shall stop its performance upon the receipt of such notice except as otherwise agreed with Buyer. If Buyer cancels the Contract, it shall pay: (a) the agreed unit price for equipment or components completed and delivered, (b) additional material and labor costs incurred, and for engineering services supplied by Seller with respect to the canceled items, which shall be charged to Buyer at Seller's rates in effect at the time of cancellation, but which shall not exceed the contract price for such items, and (c) such other costs and expenses, including cancellation charges under subcontracts, as Seller may incur in connection with such cancellation or termination.

SECTION 9: DELIVERY AND DELAYS

Seller shall use its best efforts to meet quoted delivery dates, which are estimated based on conditions known at the time of quotation. Seller shall not be liable for any nonperformance, loss, damage, or delay due to war, riots, fire, flood, strikes or other labor difficulty, governmental actions, acts of God, acts of the Buyer or its customer, delays in transportation, inability to obtain necessary labor or materials from usual sources, or other causes beyond the reasonable control of Seller. In the event of delay in performance due to any such cause, the date of delivery or time for completion will be extended to reflect the length of time lost by reason of such delay. Seller shall not be liable for any loss or damage to Buyer resulting from any delay in delivery.

SECTION 10: WARRANTY

Seller warrants that the equipment or services supplied will be free from defects in material, and workmanship for a period of 12 months from the date of initial operation of the equipment, or 18 months from the date of shipment, whichever shall first occur. In the case of spare or replacement parts manufactured by Seller, the warranty period shall be for a period of six months from shipment. Repairs shall be warranted for 12 months or, if the repair is performed under this warranty, for the remainder of the original warranty period, whichever is less. Buyer shall report any claimed defect in writing to Seller immediately upon discovery and in any event, within the warranty period. Seller shall, at its sole option, repair the equipment or furnish replacement equipment or parts thereof, at the original delivery point. Seller shall not be liable for costs of removal, reinstallation, or gaining access. If Buyer or others repair, replace, or adjust equipment or parts without Seller's prior written approval, Seller is relieved of any further obligation to Buyer under this section with respect to such equipment or parts. The repair or replacement of the equipment or spare or replacement parts by Seller under this section shall constitute Seller's sole obligation and Buyer's sole and exclusive remedy for all claims of defects. SELLER MAKES NO OTHER WARRANTY OR REPRESENTATION OF ANY KIND WITH RESPECT TO THE EQUIPMENT OR SERVICES OTHER THAN AS SPECIFIED IN THIS SECTION 10. ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

For purposes of this Section, the equipment warranted shall not include equipment, parts, and work not manufactured or performed by Seller. With respect to such equipment, parts, or work, Seller's only obligation shall be to assign to Buyer any warranty provided to Seller by the manufacturer or supplier providing such equipment, parts or work.

No equipment furnished by Seller shall be deemed to be defective by reason of normal wear and tear, failure to resist erosive or corrosive action of any fluid or gas, Buyer's failure to properly store, install, operate or maintain the equipment in accordance with good industry practices or specific recommendations of Seller, or Buyer's failure to provide complete and accurate information to Seller concerning the operational application of the equipment.

SECTION 11: TECHNICAL DOCUMENTS

Technical documents furnished by Seller to Buyer, such as drawings, descriptions, designs and the like, shall be deemed provided to Buyer on a confidential basis, shall remain Seller's exclusive property, shall not be provided in any way to third parties, and shall only be used by Buyer for purposes of installation, operation and maintenance. Technical documents submitted in connection with a Quotation that does not result in a Purchase Order shall be returned to Seller upon request.

SECTION 12: LIMITATION OF LIABILITY

Seller shall in no event be liable for any consequential, incidental, indirect, special or punitive damages arising out of the Contract, or out of any breach of any of its obligations hereunder, or out of any defect in, or failure of, or malfunction of the equipment, including but not limited to, claims based upon loss of use, lost profits or revenue, interest, lost goodwill, work stoppage, impairment of other equipment, environmental damage, nuclear incident, loss by reason of shutdown or nonoperation, increased expenses of operation, cost of purchase of replacement power or claims of Buyer or customers of Buyer for service interruption whether or not such loss or damage is based on contract, tort (including negligence and strict liability) or otherwise.

Seller's maximum liability under this Contract shall not exceed the Purchase Order amount of the equipment or portion thereof upon which such liability is based. All such liability shall terminate upon the expiration of the warranty period, if not sooner terminated.

SECTION 13: THIS COMPANY IS AN EQUAL OPPORTUNITY EMPLOYER

This agreement incorporates by reference applicable provisions and requirements of Executive Order 11246 and FAR Section 52.222-26 (covering race, color, religion, sex and national origin); the Vietnam Era Veterans Readjustment Assistance Act of 1974 and FAR Section 52.222-35 (covering special disabled and Vietnam era veterans); and the Rehabilitation Act of 1973 and FAR Section 52.222-36 (covering handicapped individuals). By acceptance of this agreement Buyer certifies that it does not and will not maintain any facilities in a segregated manner, or permit its employees to perform their services at any location under its control where segregated facilities are maintained, and further that appropriate physical facilities are maintained for both sexes. Buyer agrees that it will obtain a similar certificate prior to award of any nonexempt lower-tier subcontracts.

SECTION 14: LAW AND ARBITRATION

The Contract shall be governed by the law of the State of Texas. Any disputes arising out of this Contract shall be resolved by informal mediation in any manner that the parties may agree within 45 days of written request for mediation by one party to the other. Any dispute that cannot be resolved through mediation shall be resolved by binding arbitration conducted in English in Portland, Oregon under the Commercial Rules of the American Arbitration Association except as otherwise provided in this Section. The arbitration shall be conducted by three arbitrators chosen in accordance with said Rules. The arbitrators are not entitled to award damages in excess of compensatory damages. Judgment upon the award may be entered in any court having jurisdiction.

Check our worldwide offices at
www.paco-pumps.com

TECHNICAL BROCHURE
B3885

FEATURES

Impeller: Cast iron, semi-open, non-clog with pump-out vanes for mechanical seal protection. Balanced for smooth operation. Silicon bronze impeller available as an option.

Casing: Cast iron volute type for maximum efficiency. 2" NPT discharge.

Mechanical Seal: Silicon Carbide vs. Silicon Carbide sealing faces. Stainless steel metal parts, BUNA-N elastomers.

Shaft: Corrosion-resistant, stainless steel. Threaded design. Locknut on all models to guard against component damage on accidental reverse rotation.

Fasteners: 300 series stainless steel.

Capable of running dry without damage to components.

Designed for continuous operation when fully submerged.

EXTENDED WARRANTY AVAILABLE FOR RESIDENTIAL APPLICATIONS.

WE Series

Model 3885

SUBMERSIBLE EFFLUENT PUMPS

GOULDS
WATER TECHNOLOGY
a xylem brand

APPLICATIONS

Specifically designed for the following uses:

- Homes, Farms, Trailer Courts, Motels, Schools, Hospitals, Industry, Effluent Systems

SPECIFICATIONS

Pump

- Solids handling capabilities: ¾" maximum.
- Discharge size: 2" NPT.
- Capacities: up to 140 GPM.
- Total heads: up to 128 feet TDH.
- Temperature: 104°F (40°C) continuous, 140°F (60°C) intermittent.
- See order numbers on reverse side for specific HP, voltage, phase and RPM's available.

MOTORS

- Fully submerged in high-grade turbine oil for lubrication and efficient heat transfer.
- Class B insulation on ⅓ – 1½ HP models.
- Class F insulation on 2 HP models.

Single phase (60 Hz):

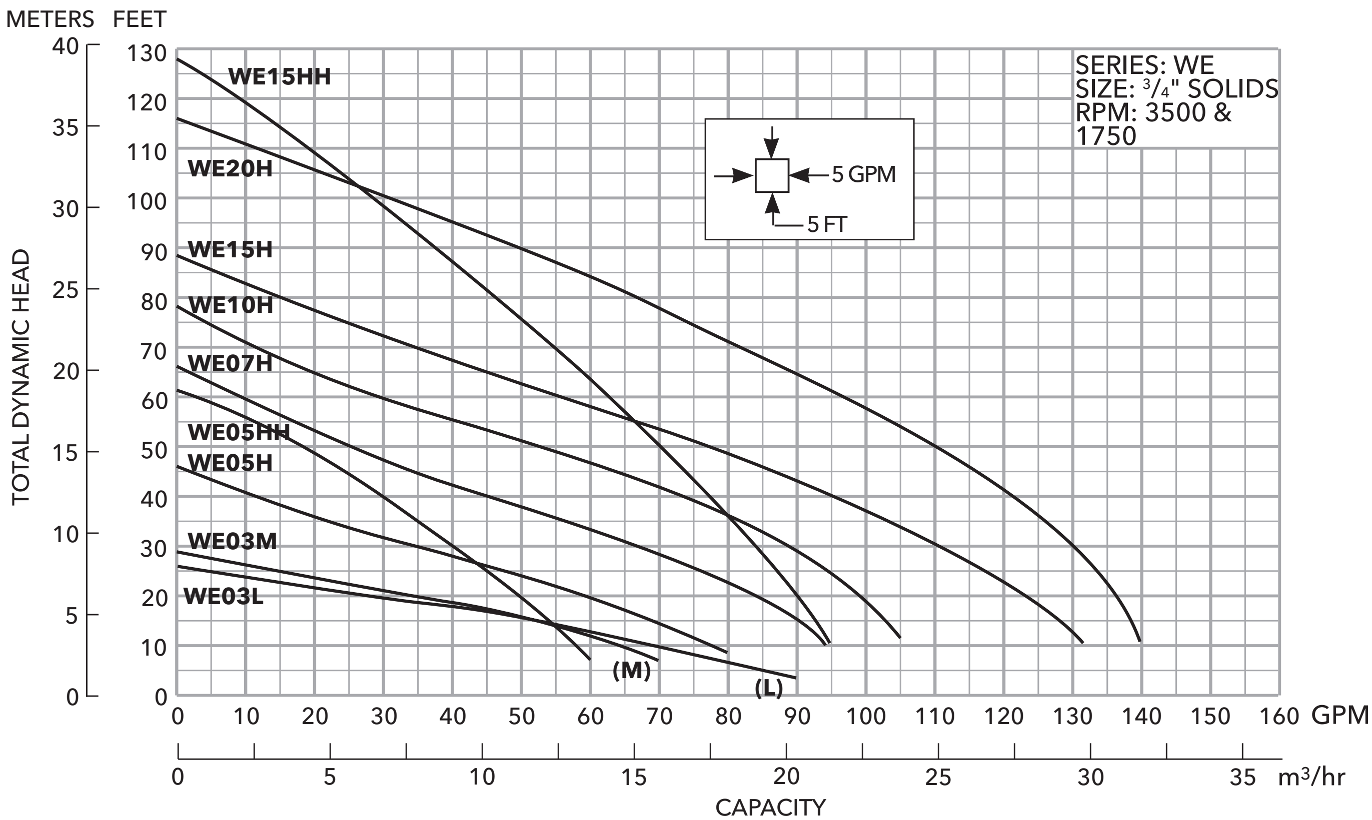
- Capacitor start motors for maximum starting torque.
- Built-in overload with automatic reset.
- SJTOW or STOW severe duty oil and water resistant power cords.
- ⅓ – 1 HP models have NEMA three prong grounding plugs.
- 1½ HP and larger units have bare lead cord ends.

Three phase (60 Hz):

- Class 10 overload protection must be provided in separately ordered starter unit.
- STOW power cords all have bare lead cord ends.
- Designed for Continuous Operation: Pump ratings are within the motor manufacturer's recommended working limits, can be operated continuously without damage when fully submerged.
- Bearings: Upper and lower heavy duty ball bearing construction.
- Power Cable: Severe duty rated, oil and water resistant. Epoxy seal on motor end provides secondary moisture barrier in case of outer jacket damage and to prevent oil wicking. Standard cord is 20'. Optional lengths are available.
- O-ring: Assures positive sealing against contaminants and oil leakage.

AGENCY LISTINGS

Tested to UL 778 and CSA 22.2 108 Standards
By Canadian Standards Association File #LR38549



MODELS

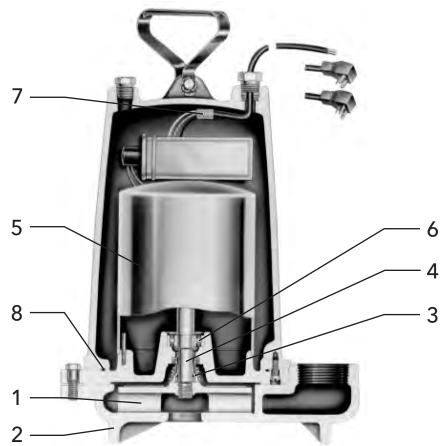
Order Number	HP	Phase	Volts	RPM	Impeller Diameter (in.)	Maximum Amps	Locked Rotor Amps	KVA Code	Full Load Efficiency %	Resistance		Power Cable Size	Weight (lbs.)
										Start	Line-Line		
WE0311L	0.33	1	115	1750	5.38	10.7	30.0	M	54	11.9	1.7	16/3	56
WE0318L			208			6.8	19.5	K	51	9.1	4.2		
WE0312L			230			4.9	14.1	L	53	14.5	8.0		
WE0311M			115			10.7	30.0	M	54	11.9	1.7		
WE0318M			208			6.8	19.5	K	51	9.1	4.2		
WE0312M			230			4.9	14.1	L	53	14.5	8.0		
WE0511H	0.5		115	3450	3.56	14.5	46.0	M	54	7.5	1.0	14/3	60
WE0518H			208			8.1	31.0	K	68	9.7	2.4	16/3	60
WE0512H			230			7.3	34.5	M	53	9.6	4.0		
WE0538H		3	200			4.9	22.6	R	68	NA	3.8	14/4	60
WE0532H			230			3.3	18.8	R	70	NA	5.8		
WE0534H			460			1.7	9.4	R	70	NA	23.2		
WE0537H			575			1.4	7.5	R	62	NA	35.3		
WE0511HH		1	115		3.88	14.5	46.0	M	54	7.5	1.0	14/3	60
WE0518HH			208			8.1	31.0	K	68	9.7	2.4	16/3	60
WE0512HH			230			7.3	34.5	M	53	9.6	4.0		
WE0538HH		3	200			4.9	22.6	R	68	NA	3.8	14/4	60
WE0532HH			230			3.6	18.8	R	70	NA	5.8		
WE0534HH			460			1.8	9.4	R	70	NA	23.2		
WE0537HH			575			1.5	7.5	R	62	NA	35.3		
WE0718H	0.75	1	208		4.06	11.0	31.0	K	68	9.7	2.4	14/3	70
WE0712H			230			10.0	27.5	J	65	12.2	2.7		
WE0738H		3	200			6.2	20.6	L	64	NA	5.7	14/4	70
WE0732H			230			5.4	15.7	K	68	NA	8.6		
WE0734H			460			2.7	7.9	K	68	NA	34.2		
WE0737H			575			2.2	9.9	L	78	NA	26.5		
WE1018H	1	1	208		4.44	14.0	59.0	K	68	9.3	1.1	14/3	70
WE1012H			230			12.5	36.2	J	69	10.3	2.1		
WE1038H		3	200			8.1	37.6	M	77	NA	2.7	14/4	70
WE1032H			230			7.0	24.1	L	79	NA	4.1		
WE1034H			460			3.5	12.1	L	79	NA	16.2		
WE1037H			575			2.8	9.9	L	78	NA	26.5		
WE1518H	1.5	1	208		4.56	17.5	59.0	K	68	9.3	1.1	14/3	80
WE1512H			230			15.7	50.0	H	68	11.3	1.6		
WE1538H		3	200			10.6	40.6	K	79	NA	1.9	14/4	80
WE1532H			230			9.2	31.7	K	78	NA	2.9		
WE1534H			460			4.6	15.9	K	78	NA	11.4		
WE1537H			575			3.7	13.1	K	75	NA	16.9		
WE1518HH		1	208		5.50	17.5	59.0	K	68	9.3	1.1	14/3	80
WE1512HH			230			15.7	50.0	H	68	11.3	1.6		
WE1538HH		3	200			10.6	40.6	K	79	NA	1.9	14/4	80
WE1532HH			230			9.2	31.7	K	78	NA	2.9		
WE1534HH			460			4.6	15.9	K	78	NA	11.4		
WE1537HH			575			3.7	13.1	K	75	NA	16.9		
WE2012H	2	1	230		5.38	18.0	49.6	F	78	3.2	1.2	14/3	83
WE2038H		3	200			12.0	42.4	K	78	NA	1.7	14/4	83
WE2032H			230			11.6	42.4	K	78	NA	1.7		
WE2034H			460			5.8	21.2	K	78	NA	6.6		
WE2037H			575			4.7	16.3	L	78	NA	10.5		

PERFORMANCE RATINGS (gallons per minute)

Order No.		WE-03L	WE-03M	WE-05H	WE-07H	WE-10H	WE-15H	WE-05HH	WE-15HH	WE-20H
	HP	⅓	⅓	½	¾	1	1½	½	1½	2
	RPM	1750	1750	3500	3500	3500	3500	3500	3500	3500
Total Head Feet of Water	5	86	–	–	–	–	–	–	–	–
	10	70	63	78	94	–	–	58	95	–
	15	52	52	70	90	103	128	53	93	138
	20	27	35	60	83	98	123	49	90	136
	25	5	15	48	76	94	117	45	87	133
	30	–	–	35	67	88	110	40	83	130
	35	–	–	22	57	82	103	35	80	126
	40	–	–	–	45	74	95	30	77	121
	45	–	–	–	35	64	86	25	74	116
	50	–	–	–	25	53	77	–	70	110
	55	–	–	–	–	40	67	–	66	103
	60	–	–	–	–	30	56	–	63	96
	65	–	–	–	–	20	45	–	58	89
	70	–	–	–	–	–	35	–	55	81
	75	–	–	–	–	–	25	–	51	74
	80	–	–	–	–	–	–	–	47	66
	90	–	–	–	–	–	–	–	37	49
	100	–	–	–	–	–	–	–	28	30

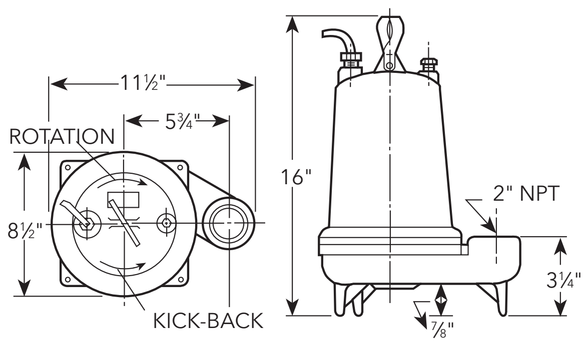
COMPONENTS

Item No.	Description
1	Impeller
2	Casing
3	Mechanical Seal
4	Motor Shaft
5	Motor
6	Ball Bearings
7	Power Cable
8	Casing O-Ring



DIMENSIONS

(All dimensions are in inches. Do not use for construction purposes.)



xylem
Let's Solve Water

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www.xyleminc.com/brands/gouldswatertechnology

INSTRUCTION MANUAL
IM107R06

Wastewater Pumps
Dewatering, Effluent and Sewage

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

GOULDS WATER TECHNOLOGY
a xylem brand

TABLE OF CONTENTS

Owner's Information

Pump Model Number: ______________________

Pump Serial Number: ______________________

Control Model Number: ______________________

Dealer: ______________________

Dealer Phone No. ______________________

Date of Purchase: __________ Installation: __________

Current Readings at Startup:

1Ø	3Ø	L1-2	L2-3	L3-1
Amps: ______	Amps:	______	______	______
Volts: ______	Volts:	______	______	______

SAFETY INSTRUCTIONS

TO AVOID SERIOUS OR FATAL PERSONAL INJURY OR MAJOR PROPERTY DAMAGE, READ AND FOLLOW ALL SAFETY INSTRUCTIONS IN MANUAL AND ON PUMP.

THIS MANUAL IS INTENDED TO ASSIST IN THE INSTALLATION AND OPERATION OF THIS UNIT AND MUST BE KEPT WITH THE PUMP.

This is a **SAFETY ALERT SYMBOL.** When you see this symbol on the pump or in the manual, look for one of the following signal words and be alert to the potential for personal injury or property damage.

DANGER Warns of hazards that **WILL** cause serious personal injury, death or major property damage.

WARNING Warns of hazards that **CAN** cause serious personal injury, death or major property damage.

CAUTION Warns of hazards that **CAN** cause personal injury or property damage.

NOTICE: INDICATES SPECIAL INSTRUCTIONS WHICH ARE VERY IMPORTANT AND MUST BE FOLLOWED.

THOROUGHLY REVIEW ALL INSTRUCTIONS AND WARNINGS PRIOR TO PERFORMING ANY WORK ON THIS PUMP.

MAINTAIN ALL SAFETY DECALS.

WARNING All electrical work must be performed by a qualified technician. Always follow the National Electrical Code (NEC), or the Canadian Electrical Code, as well as all local, state and provincial codes. Code questions should be directed to your local electrical inspector. Failure to follow electrical codes and OSHA safety standards may result in personal injury or equipment damage. Failure to follow manufacturer's installation instructions may result in electrical shock, fire hazard, personal injury or death, damaged equipment, provide unsatisfactory performance, and may void manufacturer's warranty.

WARNING Standard units are not designed for use in swimming pools, open bodies of water, hazardous liquids, or where flammable gases exist. These fluids and gases may be present in containment areas. Tank or wetwell must be vented per local codes.

Only pumps specifically Listed for Class 1, Division 1 are allowable in hazardous liquids and where flammable gases may exist. *See specific pump catalog bulletins or pump nameplate for all agency Listings*.

WARNING Disconnect and lockout electrical power before installing or servicing any electrical equipment. Many pumps are equipped with automatic thermal overload protection which may allow an overheated pump to restart unexpectedly.

CAUTION All three phase (3Ø) control panels for submersible pumps must provide Class 10, quick-trip, overload protection.

PRE-INSTALLATION CHECKS

Open all cartons and inspect for shipping damage. Report any damage to your supplier or shipping carrier immediately.

Important: Always verify that the pump nameplate Amps, Voltage, Phase and HP ratings match your control panel and power supply.

Many of our sewage pumps are oil-filled. If there are any signs of oil leakage or if the unit has been stored for an extended period check the oil level in the motor dome and the seal housing, if so equipped.

Check the motor cover oil level through the pipe plug on top of the unit. The motor chamber oil should just cover the motor. Do not overfill, leave room for expansion!

To check the seal housing oil level, where used, lay the unit on its side with the fill plug at 12 o'clock. Remove the plug. The oil should be within ½" (13mm) of the top. If low, refill with an ASTM 150 turbine oil. Replace the plug.

You can source oil locally at motor repair shops. Typical oil brands are: Shell Turbo 32, Sunoco Sunvis 932, Texaco Regal R&O 32, Exxon Nuto 32 and Mobil DTE Light.

Check the strain relief nut on power cable strain assemblies. Power cables should be torqued to 75 in. lbs. for #16 cables and 80 in. lbs. for all other cable assemblies. Seal/heat sensor cables, where used, should be torqued to 75 in. lbs.

Warranty does not cover damage caused by connecting pumps and controls to an incorrect power source (voltage/phase supply).

Record the model numbers and serial numbers from the pumps and control panel on the front of this instruction manual for future reference. Give it to the owner or affix it to the control panel when finished with the installation.

LIFTING OF PUMP

DO NOT LIFT, CARRY OR HANG PUMP BY THE ELECTRICAL CABLES. DAMAGE TO THE ELECTRICAL CABLES CAN CAUSE SHOCK, BURNS OR DEATH.

Lift the pump with an adequately sized chain or cable attached to the lifting eye bolt. **DO NOT** damage electrical and sensor cables while raising and lowering unit.

OPTIONAL GUIDE RAIL OR LIFT-OUT SYSTEM

In many effluent and sewage basins or lift stations it is advisable to install the pump on a guide rail system or on a lift-out adapter to facilitate installation and removal for inspection and/or service. Most codes do not allow personnel to enter a wetwell without the correct protective equipment and training. Guide rails are designed to allow easy removal of the pump without the need for entry into the wetwell or need to disturb piping. The guide rail or lift-out adapter should locate the pump opposite the influent opening preventing stagnate areas where solids can settle.

The basin or pit must be capable of supporting the weight of the pump and guide rail. The pit floor must be flat.

NOTICE: FOLLOW THE INSTRUCTIONS THAT ARE PROVIDED WITH THE GUIDE RAIL ASSEMBLY.

PIPING

Discharge piping should be no smaller than the pump discharge diameter and kept as short as possible, avoiding unnecessary fittings to minimize friction losses.

Install an adequately sized check valve matched to the solids handling capability of the pump to prevent fluid backflow. Backflow can allow the pump to spin backwards and may cause premature seal, bearing, shaft wear. If the pump is turning backwards when it is called on to start the increased torque may cause damage to the pump motor and/or motor shaft.

Install an adequately sized gate valve **AFTER** the check valve for pump, plumbing and check valve maintenance.

Important – Before pump installation. Drill a 3⁄16" (4.8mm) relief hole in the discharge pipe. It should be located within the wetwell, 2" (51mm) above the pump discharge but below the check valve. The relief hole allows any air to escape from the casing. Allowing liquid into the casing will insure that the pump can start when the liquid level rises. Unless a relief hole is provided, a bottom intake pump could "air lock" and will not pump water even though the impeller turns.

All piping must be adequately supported, so as not to impart any piping strain or loads on the pump.

The pit access cover must be of sufficient size to allow for inspection, maintenance and crane or hoist service.

WIRING AND GROUNDING

Important notice: Read Safety Instructions before proceeding with any wiring.

⚠ Use only stranded copper wire to pump/motor and ground. The ground wire must be at least as large as the power supply wires. Wires should be color coded for ease of maintenance and troubleshooting.

⚠ Install wire and ground according to the National Electrical Code (NEC), or the Canadian Electrical Code, as well as all local, state and provincial codes.

⚠ Install an all leg disconnect switch where required by code.

⚠ Disconnect and lockout electrical power before performing any service or installation.

⚠ The electrical supply voltage and phase must match all equipment requirements. Incorrect voltage or phase can cause fire, motor and control damage, and voids the warranty.

⚠ All splices must be waterproof. If using splice kits follow manufacturer's instructions.

⚠WARNING Select the correct type and NEMA grade junction box for the application and location. The junction box must insure dry, safe wiring connections.

⚠WARNING Seal all controls from gases present which may damage electrical components.

⚠WARNING Hazardous voltage

FAILURE TO PERMANENTLY GROUND THE PUMP, MOTOR AND CONTROLS BEFORE CONNECTING TO POWER CAN CAUSE SHOCK, BURNS OR DEATH.

SELECTING AND WIRING PUMP CONTROL PANELS AND SWITCHES

FLOAT SWITCH TYPES

There are two basic float switch designs; single-action and wide-angle. Single-action switches operate over a range of 15° so they open and close quickly. Wide-angle floats operate over a 90° swing with the tether length between the float body and the pivot point controlling the On-Off range. The design determines how many floats are required with different systems or controls.

Floats may be normally open (NO) for pump down applications or to empty a tank. Normally closed (NC) switches are used to pump up or to fill a tank.

A single-action control switch may be used only with a control panel, never direct connected to a pump.

The wide-angle, pump down switches may be used as direct connected pump switches or as control switches.

SETTING THE FLOAT SWITCHES

There are no absolute rules for where to set the float switches, it varies from job to job.

Suggested Rules to Follow:
All floats should be set below the Inlet pipe!

Off Float: Best: set so free hanging the water level is always above the top of the pump (motor dome). **Next Best:** set so the water level is not more than 6" below the top of the pump.

On Float: set so the volume of water between the On and Off floats allows pumps of 1½ HP and under to operate for 1 minute minimum. Two (2) HP and larger pumps should run a minimum of 2 minutes. Basin technical brochure states the gallons of storage per inch of basin height.

Lag/Alarm Float(s): should be staggered above the Off and On floats. Try to use most of the available storage provided by the basin, save some space for reserve storage capacity. Exact reserve may be called out by local codes. *See Diagrams and Charts in Float Switch Chart Section.*

PANEL WIRING DIAGRAMS

Our control panels are shipped with instructions and wiring diagrams. Use those instructions in conjunction with this IOM. Electrical installation should be performed only by qualified technicians. Any problem or questions pertaining to another brand control must be referred to that control supplier or manufacturer.

ALARMS

We recommend the installation of an alarm on all Wastewater pump installations. Many standard control panels come equipped with alarm circuits. If a control panel is not used, a stand alone high liquid level alarm is available. The alarm alerts the owner of a high liquid level in the basin so they can contact the appropriate service personnel to investigate the situation.

SINGLE PHASE PUMPS

Single phase (1Ø) pumps may be operated using a piggyback or in conjunction with, or a Simplex or Duplex control panel. *See Figures 1, 2 and 5.*

Most 1/3 and 1/2 HP, 115 or 230 volt pumps, and some 3/4 and 1 HP pumps, are supplied with plug style power cords. They may be plugged into piggyback float switches for simple installations. It is allowable to remove the plugs in order to hardwire or connect to a Simplex or Duplex controller. Removing the plug neither voids the warranty nor violates the agency Listings. *See Figure 5.*

PLUG-CONNECTED UNITS MUST BE CONNECTED TO A PROPERLY GROUNDED, GROUNDING TYPE RECEPTACLE.

ON NON-PLUG UNITS, DO NOT REMOVE CORD AND STRAIN RELIEF. DO NOT CONNECT CONDUIT TO PUMP.

Pumps with bare lead power cords can be hard-wired to a float switch, wired to a 1Ø contactor, a Simplex controller or a Duplex controller. Always verify that the float switch is rated for the maximum run amperage, maximum starting amperage, and the HP rating on the pump. Single-phase wastewater pumps contain on-winding overloads, unless noted on the pump nameplate. *See Figures 1 and 2.*

THREE PHASE PUMPS:
As a Minimum a 3Ø pump requires a 3 pole circuit breaker/fused circuit, an across the line magnetic starter rated for the pump HP, and ambient compensated Quick Trip Class 10 overloads.

SINGLE AND THREE PHASE CONTROL PANELS:
Control panels are available as Simplex (controls 1 pump) or Duplex (controls 2 pumps). Our standard SES Series Panels are available with many standard features and can be built with our most popular options. We also custom build panels which offer many more design options. Custom control panels are available in many different configurations. Custom panel quote requests may be forwarded to Customer Service through any authorized distributor.

Our duplex panels feature a solid-state printed circuit board design with standard high level alarm circuits. Other standard features are: an auxiliary dry alarm contact for signaling a remote alarm and float switch position indicator lights. Our 3Ø panels have built-in, adjustable, Class 10 overloads. The adjustable overloads on all our 3Ø panels mean less labor for the installer and no need to order specific overloads. Most panels are in stock for immediate delivery without options.

Heat Sensor and Seal Failure Circuit - Some Pumps are equipped with a seal failure circuit and a Heat sensor. On standard product the seal failure circuit, if supplied without Heat sensor will have an extra lead from the motor with two conductors. These leads will be Black and White and should be connected to the seal failure terminals in a panel supplied with this option. If a seal failure circuit and Heat sensor are supplied with the pump there will be a separate lead with four conductors. For these leads the connection for seal failure will be Black and Green and the Heat sensor will be Red and White. The model 1GD/12GDS can be ordered with an optional seal failure circuit, but most dual seal pumps come with the seal failure circuit as a standard.

Models with a 4NS/4DWC/4XD/4XWS have a standard configuration with seal failure and heat sensor. The leads are in a separate jacket with 5 leads. Black (tagged P1) and White (tagged P2) should be connected to thermal protection terminals. The seal fail leads are Red (tagged W1) and Orange (tagged W2) and should be connected to the seal fail terminals. The additional lead is Green and should be connected to Ground. Panels will come equipped with a wiring diagram designating your connections. Panels must be ordered with the options for seal failure circuits and heat sensor circuits, since these panels can also be used on pumps without the option for these connections they do not come as standard on most panels.

One additional style of seal failure and heat sensor circuits is our product sold with models GA(X) / 15GDS(X) / 20GDS(X); 2, 3, 4GV(X); 2, 3, 4MV(X); 2, 3, 4, 6MK(X). These units come with a single lead for power and controls. The conductor will come with 7 leads (previous to January 2013). Leads For seal failure and heat sensor will be Orange and Blue. Since these units use a different style sensor in the pump as well as a different option in the panel the connections require only two leads. After January 2013 the lead colors on the pumps were changed to two (2) white leads for the seal failure and heat sensor.

Be careful to choose the correct options in the panel selection for each style pump. Always follow wiring schematic of the panel. Failure to wire the seal failure and heat sensor leads correctly may prevent the pump from running or cause nuisance tripping.

INSTALLATION

Connect the pump(s) to the guide rail pump adapters or to the discharge piping. Slide rail bases should be anchored to the wetwell floor.

Complete all wiring per the control panel wiring diagrams and NEC, Canadian, state, provincial and/or local codes. This a good time to check for proper rotation of the motors/impellers.

DO NOT PLACE HANDS IN PUMP SUCTION WHILE CHECKING MOTOR ROTATION. TO DO SO WILL CAUSE SEVERE PERSONAL INJURY.

Always verify correct rotation. Correct rotation is indicated on the pump casing. Three phase motors are reversible. It is allowable to bump or jog the motor for a few seconds to check impeller rotation. It is easier to check rotation before installing the pump. Switch any two power leads to reverse rotation.

Lower the pump(s) into the wetwell.

Check to insure that the floats will operate freely and not contact the piping.

OPERATION

Once the piping connections are made and checked you can run the pumps.

Piggyback Switch Operation – Plug the piggyback switch into a dedicated grounded outlet and then plug the pump into the switch. Test the pump by filling the wetwell until the pump goes On. If the pumps run but fail to pump, they are probably air locked, drill the relief holes per the instructions in the Piping Section.

Check the operating range to insure a minimum one minute run time and that the pump goes Off in the correct position.

Control Panel Operation – Fill the wetwell with clear water.

Use the pump H-O-A (Hand-Off-Automatic) switches in Hand to test the pumps. If they operate well in Hand proceed to test Automatic operation. If the pumps run but fail to pump, they are probably air locked, drill the relief holes per the instructions in the Piping Section.

Place Control Panel switch(es) in Automatic position and thoroughly test the operation of the ON, OFF, and Alarm floats by filling the wetwell with clear water. **Important:** Failure to provide a Neutral from the power supply to a 1Ø, 230 volt Control Panel will not allow the panel control circuit to operate. The Neutral is necessary to complete the 115 volt control circuit.

Check voltage and amperage and record the data on the front of this manual for future reference. Compare the amperage readings to the pump nameplate maximum amperage. If higher than nameplate amperage investigate cause.

Operating the pump off the curve, i.e. with too little head or with high or low voltage will increase amperage. The motor will operate properly with voltage not more than 10% above or below pump nameplate ratings. Performance within this range will not necessarily be the same as the published performance at the exact rated nameplate frequency and voltage. Correct the problem before proceeding. Three phase unbalance is also a possible cause. *See Three Phase Power Unbalance and follow the instructions*.

Reset the Alarm circuit, place pump switch(es) in the Automatic position and Control Switch in ON position. The system is now ready for automatic operation.

Explain the operation of the pumps, controls and alarms to the end user. Leave the paperwork with the owner or at the control panel if in a dry, secure location.

FLOAT SWITCH AND PANEL CHART

The purpose of this chart is to show the required switch quantities and the function of each switch in a typical wastewater system. The quantities required vary depending on the switch type, single-action or wide-angle. Switch quantities also vary by panel type: simplex with and without alarms, and duplex with alarms.

Duplex Panels using single-action switches:

Three Float Panel Wiring

SW1	Bottom	Pumps Off
SW2	Middle	1st Pump On
SW3	Top	2nd Pump & Alarm On

Four Float Panel Wiring ②

SW1	Bottom	Pumps Off
SW2	2nd	1st Pump On
SW3	3rd	2nd Pump On
SW4	Top	Alarm On

Duplex Panels using wide-angle switches:

Three Float Panel Wiring

SW1	Bottom	1st Pump On/Both Off
SW2	Top	2nd Pump & Alarm On

Four Float Panel Wiring

SW1	Bottom	1st Pump On/Both Off
SW2	Middle	2nd Pump On
SW3	Top	Alarm On

Simplex Panel using single-action switches:

Simplex Panel with Alarm ①

SW1	Bottom	Pump Off
SW2	Middle	Pump On
SW3	Top	Alarm On/Off

Simplex Panel with No Alarm

SW1	Bottom	Pump Off
SW2	Top	Pump On

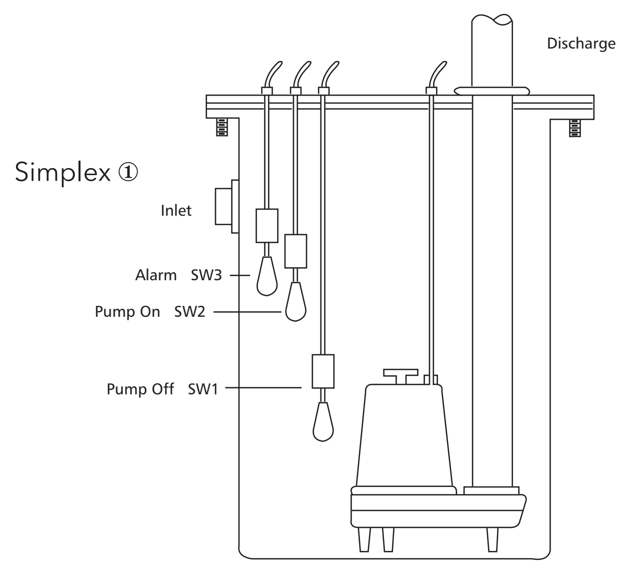
Simplex Panel using wide-angle switches:

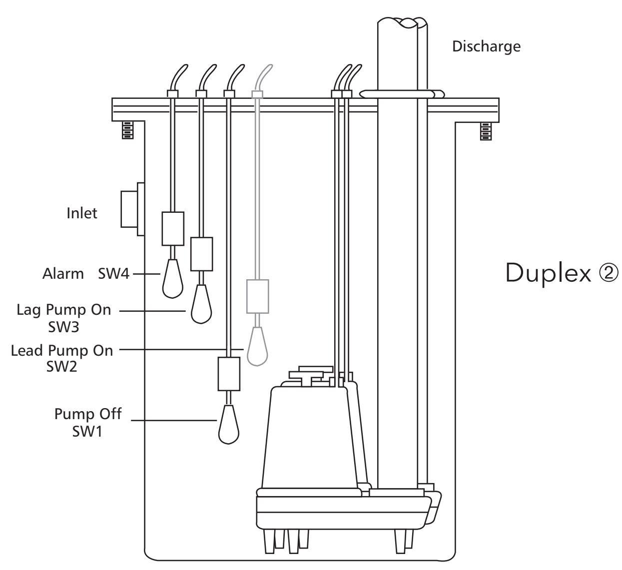
Simplex Panel with Alarm

SW1	Bottom	Pump On/Off
SW2	Top	Alarm On/Off

Simplex Panel with No Alarm

SW1		Pump On/Off





THREE PHASE POWER UNBALANCE

A full three phase supply consisting of three individual transformers or one three phase transformer is recommended. “Open” delta or wye connections using only two transformers can be used, but are more likely to cause poor performance, overload tripping or early motor failure due to current unbalance.

Check the current in each of the three motor leads and calculate the current unbalance as explained below.

If the current unbalance is 2% or less, leave the leads as connected.

If the current unbalance is more than 2%, current readings should be checked on each leg using each of the three possible hook-ups. Roll the motor leads across the starter in the same direction to prevent motor reversal.

To calculate percent of current unbalance:

A. Add the three line amp values together.

B. Divide the sum by three, yielding average current.

C. Pick the amp value which is furthest from the average current (either high or low).

D. Determine the difference between this amp value (furthest from average) and the average.

E. Divide the difference by the average. Multiply the result by 100 to determine percent of unbalance.

Current unbalance should not exceed 5% at service factor load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the power source.

Contact your local power company to resolve the imbalance.

	Hookup 1			Hookup 2			Hookup 3		
Starter Terminals	L1	L2	L3	L1	L2	L3	L1	L2	L3
Motor Leads	R	B	W	W	R	B	B	W	R
	T3	T1	T2	T2	T3	T1	T1	T2	T3

Example:

Hookup 1	Hookup 2	Hookup 3
T3-R = 51 amps	T2-W = 50 amps	T1-B = 50 amps
T1-B = 46 amps	T3-R = 48 amps	T2-W = 49 amps
T2-W = 53 amps	T1-B = 52 amps	T3-R = 51 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
÷ 3 = 50 amps	÷ 3 = 50 amps	÷ 3 = 50 amps
– 46 = 4 amps	– 48 = 2 amps	– 49 = 1 amps
4 ÷ 50 = .08 or 8%	2 ÷ 50 = .04 or 4%	1 ÷ 50 = .02 or 2%

INSULATION RESISTANCE READINGS

Normal Ohm and Megohm Values between all leads and ground

Condition of Motor and Leads	Ohm Value	Megohm Value
A new motor (without drop cable).	20,000,000 (or more)	20 (or more)
A used motor which can be reinstalled in well.	10,000,000 (or more)	10 (or more)
Motor in well. Readings are for drop cable plus		
New motor.	2,000,000 (or more)	2 (or more)
Motor in good condition.	500,000 - 2,000,000	.5 - 2
Insulation damage, locate and repair.	Less than 500,000	Less than .5

Insulation resistance varies very little with rating. Motors of all HP, voltage and phase ratings have similar values of insulation resistance.

Insulation resistance values above are based on readings taken with a megohmmeter with a 500V DC output. Readings may vary using a lower voltage ohmmeter, consult factory if readings are in question.

Engineering data for specific models may be found in your catalog and on our website (address is on the cover).

Control panel wiring diagrams are shipped with the control panels. Please use the control panel drawings in conjunction with this instruction manual to complete the wiring.

PUMP OPERATION

Minimum Submergence	
Continuous Duty	Fully Submerged
Intermittent Duty	6" Below Top of Motor

Maximum Fluid Temperature	
Continuous Operation	104° F 40° C
Intermittent Operation	140° F 60° C

NOT RECOMMENDED
Pumpmaster and Pumpmaster Plus - Hard Wired

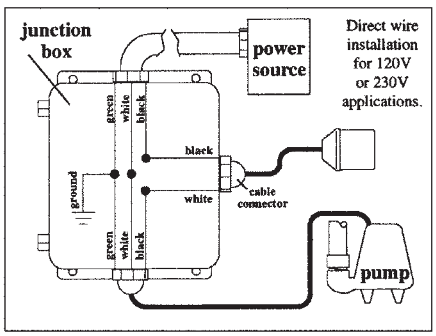


Figure 1

Single-Action Float Switch "Typical" Installation

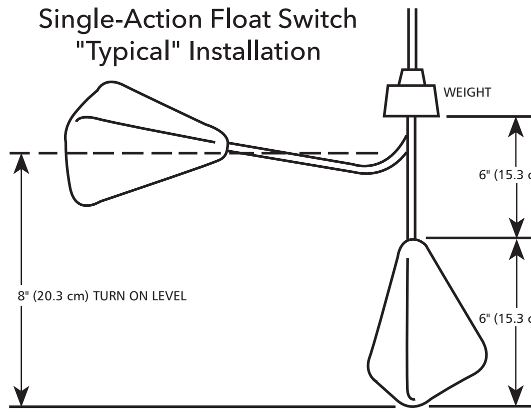


Figure 4

NOT RECOMMENDED
Double Float - Hard Wired

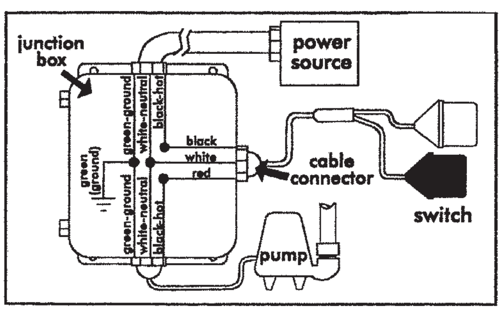


Figure 2

Wide-Angle Float Switch

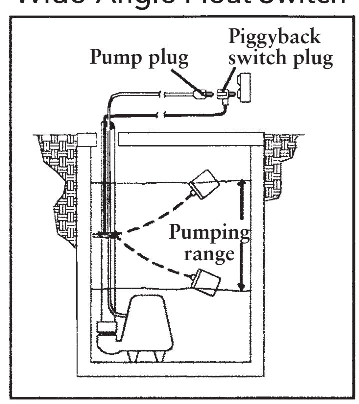


Figure 5

Determining Pumping Range

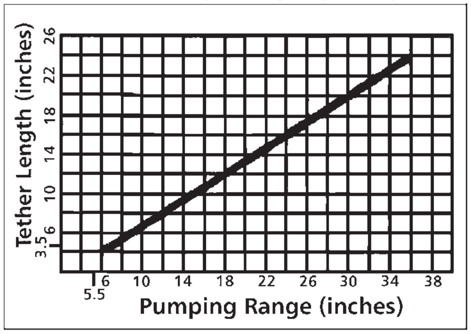


Figure 3

Three Phase Connection Diagram

Standard without seal failure and heat sensor for powering pump.

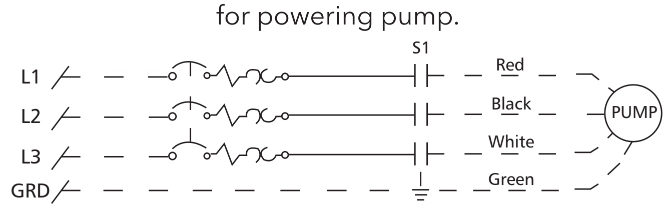


Figure 6

Three Phase Standard Product Leads

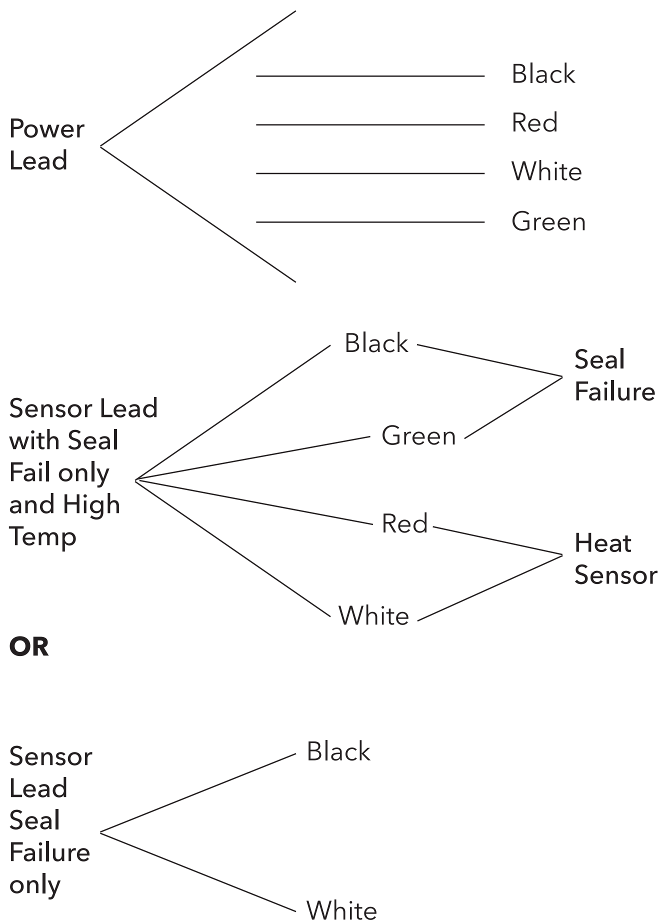


Figure 7

4NS/4XD/4XS/4DWC

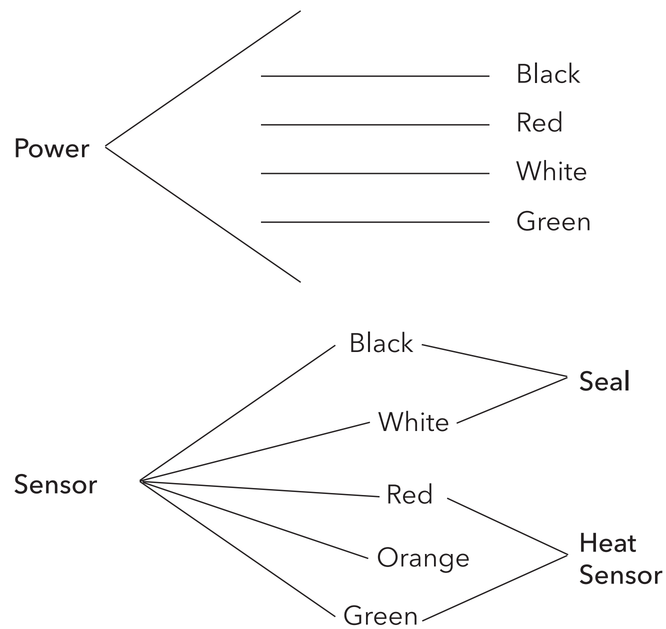


Figure 9

1/2GA(X), 15/20GDS(X)

2, 3, 4GV(X) – 2, 3, 4, 6MK(X) – 2, 3, 4MV(X)

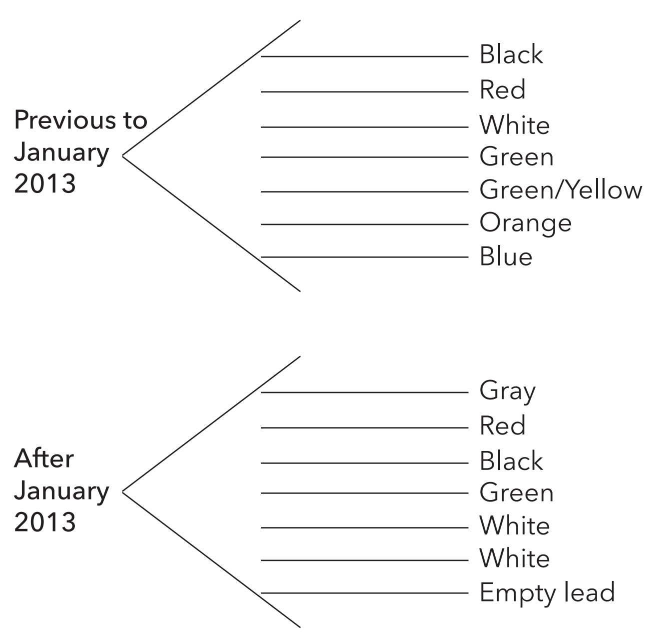
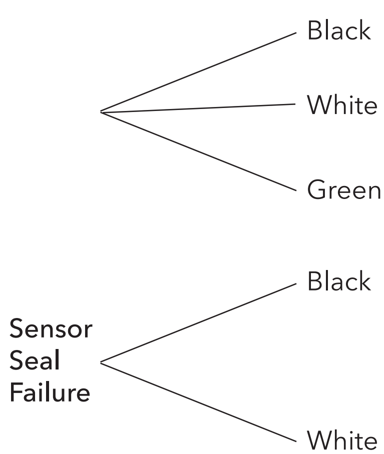


Figure 10

Single Phase



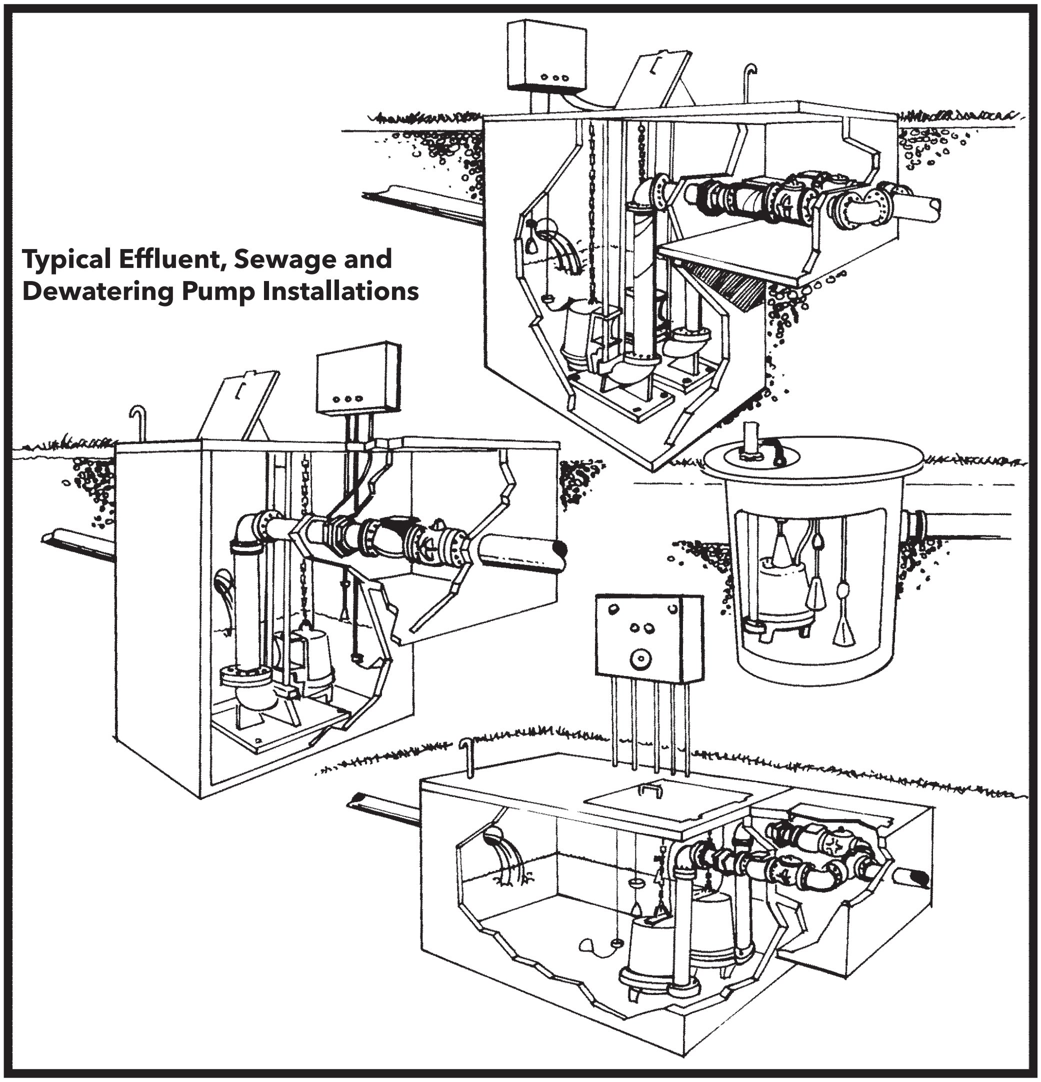
No Heat Sensor available

Figure 8

⚠WARNING
Hazardous voltage

FAILURE TO DISCONNECT AND LOCKOUT ELECTRICAL POWER BEFORE ATTEMPTING ANY SERVICE CAN CAUSE SHOCK, BURNS OR DEATH.

SYMPTOM	PROBABLE CAUSE	RECOMMENDED ACTION
MOTOR NOT RUNNING	Motor thermal protector tripped.	Allow motor to cool. Insure minimum pump submergence. Clear debris from casing and impeller.
NOTE: If circuit breaker "OPENS" repeatedly, **DO NOT** reset. Call qualified electrician.	Open circuit breaker or blown fuse.	Determine cause, call a qualified electrician.
	Pump impeller binding or jammed.	Check motor amp draw. If two or more times higher than listed on pump nameplate, impeller is locked, motor bearings or shaft is damaged. Clear debris from casing and impeller, consult with dealer.
a) Manual operation	Power cable is damaged. Inadequate electrical connection in control panel.	Resistance between power leads and ground should read infinity. If any reading is incorrect, call a qualified electrician.
b) Automatic operation	No neutral wire connected to control panel.	
	Inadequate electrical connection in control panel.	Inspect control panel wiring. Call a qualified electrician.
NOTE: Check the pump in manual mode first to confirm operation. If pump operates, the automatic control or wiring is at fault. If pump does not operate, see above.	Defective liquid level switch.	With switch disconnected, check continuity while activating liquid level switch. Replace switch, as required.
	Insufficient liquid level to activate controls.	Allow liquid level to rise 3" to 4" (76 mm - 101 mm) above turn-on level.
	Liquid level cords tangled.	Untangle cords and insure free operation.
PUMP WILL NOT TURN OFF	Liquid level cords tangled.	Untangle cords and insure free operation.
	Pump is air locked.	Shut off pump for approximately one minute, then restart. Repeat until air lock clears. If air locking persists in a system with a check valve, a 3⁄16" (4.8 mm) hole may be drilled in the discharge pipe approximately 2" (51 mm) above the discharge connection.
	Influent flow is matching pump's discharge capacity.	Larger pump may be required.
LITTLE OR NO LIQUID DELIVERED BY PUMP	Check valve installed backwards, plugged or stuck closed.	Check flow arrow on valve and check valve operation.
	Excessive system head.	Consult with dealer.
	Pump inlet plugged.	Inspect and clear as required.
	Improper voltage or wired incorrectly.	Check pump rotation, voltage and wiring. Consult with qualified electrician.
	Pump is air locked.	See recommended action, above.
	Impeller is worn or damaged.	Inspect impeller, replace as required.
	Liquid level controls defective or improperly positioned.	Inspect, readjust or replace as required.
PUMP CYCLES CONSTANTLY	Discharge check valve inoperative.	Inspect, repair or replace as required.
	Sewage containment area too small.	Consult with dealer.
	Liquid level controls defective or improperly positioned.	Inspect, readjust or replace as required.
	Influent excessive for this size pump.	Consult with dealer.



GOULDS WATER TECHNOLOGY LIMITED WARRANTY

This warranty applies to all water systems pumps manufactured by Goulds Water Technology.

Any part or parts found to be defective within the warranty period shall be replaced at no charge to the dealer during the warranty period. The warranty period shall exist for a period of twelve (12) months from date of installation or eighteen (18) months from date of manufacture, whichever period is shorter.

A dealer who believes that a warranty claim exists must contact the authorized Goulds Water Technology distributor from whom the pump was purchased and furnish complete details regarding the claim. The distributor is authorized to adjust any warranty claims utilizing the Goulds Water Technology Customer Service Department.

The warranty excludes:

(a) Labor, transportation and related costs incurred by the dealer;
(b) Reinstallation costs of repaired equipment;
(c) Reinstallation costs of replacement equipment;
(d) Consequential damages of any kind; and,
(e) Reimbursement for loss caused by interruption of service.

For purposes of this warranty, the following terms have these definitions:

(1) "Distributor" means any individual, partnership, corporation, association, or other legal relationship that stands between Goulds Water Technology and the dealer in purchases, consignments or contracts for sale of the subject pumps.
(2) "Dealer" means any individual, partnership, corporation, association, or other legal relationship which engages in the business of selling or leasing pumps to customers.
(3) "Customer" means any entity who buys or leases the subject pumps from a dealer. The "customer" may mean an individual, partnership, corporation, limited liability company, association or other legal entity which may engage in any type of business.

THIS WARRANTY EXTENDS TO THE DEALER ONLY.

xylem
Let's Solve Water

Xylem Inc.
2881 East Bayard Street Ext., Suite A
Seneca Falls, NY 13148
Phone: (866) 325-4210
Fax: (888) 322-5877
www.gouldswatertechnology.com

Reference Manual
00809-0100-4001, Rev JA
November 2012

Rosemount 3051 Pressure Transmitter

with HART® Protocol

ROSEMOUNT

www.emersonprocess.com/rosemount

EMERSON.
Process Management

Rosemount 3051 Pressure Transmitter

⚠ WARNING

Read this manual before working with the product. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product.

For technical assistance, contacts are listed below:

Customer Central
Technical support, quoting, and order-related questions.

United States - 1-800-999-9307 (7:00 am to 7:00 pm CST)

Asia Pacific- 65 777 8211

Europe/ Middle East/ Africa - 49 (8153) 9390

North American Response Center
Equipment service needs.

1-800-654-7768 (24 hours—includes Canada)

Outside of these areas, contact your local Emerson Process Management representative.

⚠ CAUTION

The products described in this document are NOT designed for nuclear-qualified applications. Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Rosemount nuclear-qualified products, contact your local Emerson Process Management Sales Representative.

Contents

Section 3: Configuration

Section 4: Operation and maintenance

Section 5: Troubleshooting

Appendix A: Specifications and reference data

Appendix B: Product certifications

Section 1 Introduction

1.1 Using this manual

The sections in this manual provide information on installing, operating, and maintaining the Rosemount 3051. The sections are organized as follows:

Section 2: Installation contains mechanical and electrical installation instructions, and field upgrade options.

Section 3: Configuration provides instruction on commissioning and operating Rosemount 3051 transmitters. Information on software functions, configuration parameters, and online variables is also included.

Section 4: Operation and maintenance contains operation and maintenance techniques.

Section 5: Troubleshooting provides troubleshooting techniques for the most common operating problems.

Appendix A: Specifications and reference data supplies reference and specification data, as well as ordering information.

Appendix B: Product certifications contains intrinsic safety approval information, European ATEX directive information, and approval drawings.

1.2 Service support

To expedite the return process outside of the United States, contact the nearest Emerson Process Management representative.

Within the United States, call the Emerson Process Management Instrument and Valve Response Center using the 1-800-654-RSMT (7768) toll-free number. This center, available 24 hours a day, will assist you with any needed information or materials.

The center will ask for product model and serial numbers, and will provide a Return Material Authorization (RMA) number. The center will also ask for the process material to which the product was last exposed.

⚠CAUTION

Individuals who handle products exposed to a hazardous substance can avoid injury if they are informed of and understand the hazard. The product being returned will require a copy of the required Material Safety Data Sheet (MSDS) for each substance must be included with the returned goods.

Emerson Process Management Instrument and Valve Response Center representatives will explain the additional information and procedures necessary to return goods exposed to hazardous substances.

1.3 Models covered

The following Rosemount 3051 Pressure Transmitters are covered by this manual:

Rosemount 3051C coplanar pressure transmitter

Rosemount 3051CD Differential Pressure Transmitter

Measures differential pressure up to 2000 psi (137,9 bar).

Rosemount 3051CG Gage Pressure Transmitter

Measures gage pressure up to 2000 psi (137,9 bar).

Rosemount 3051CA Absolute Pressure Transmitter

Measures absolute pressure up to 4000 psia (275,8 bar).

Rosemount 3051T in-line pressure transmitter

Rosemount 3051T Gage and Absolute Pressure Transmitter

Measures gage pressure up to 10000 psi (689,5 bar).

Rosemount 3051L liquid level transmitter

Provides precise level and specific gravity measurements up to 300 psi (20,7 bar) for a wide variety of tank configurations.

Rosemount 3051H high process temperature pressure transmitter

Provides high process temperature capability to 375 °F (191 °C) for measuring differential or gage pressure without use of remote diaphragm seals or capillaries.

Note
For Rosemount 3051 with FOUNDATION™ fieldbus, see Rosemount Product Manual 00809-0100-4774. For Rosemount 3051 with Profibus PA, see Rosemount Product Manual 00809-0100-4797.

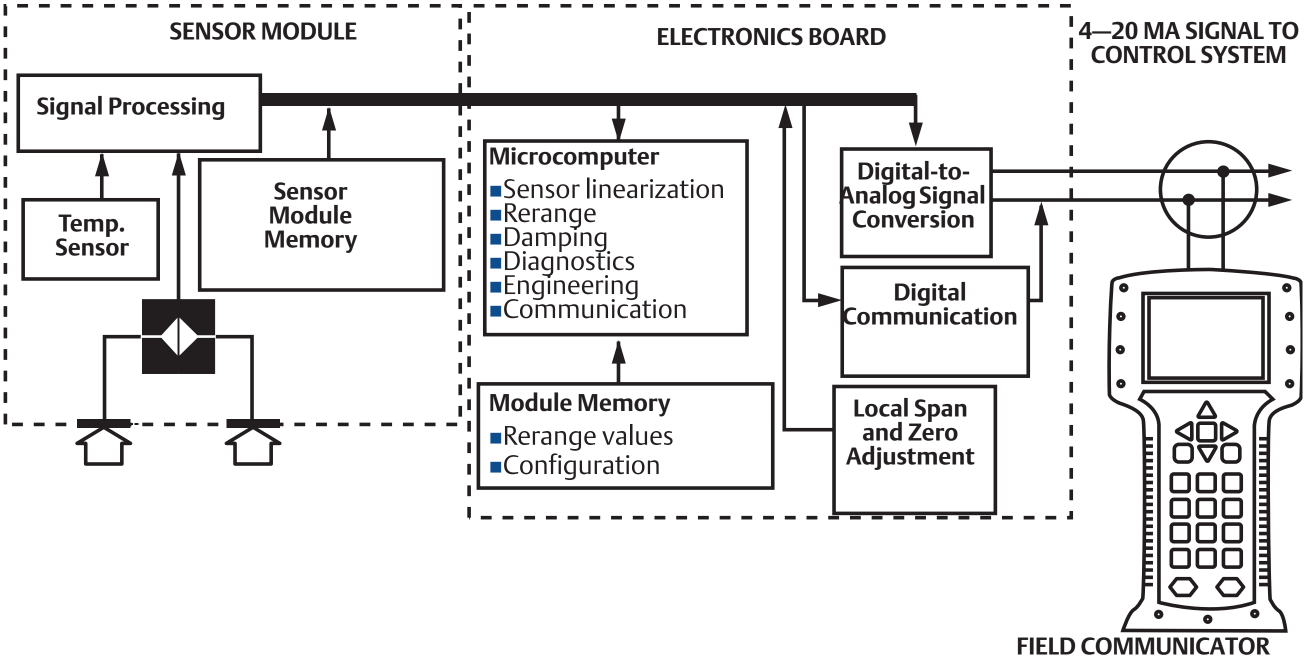
1.4 Transmitter overview

The Rosemount 3051C Coplanar™ design is offered for Differential Pressure (DP), Gage Pressure (GP) and Absolute Pressure (AP) measurements. The Rosemount 3051C utilizes Emerson Process Management capacitance sensor technology for DP and GP measurements. Piezoresistive sensor technology is utilized in the Rosemount 3051T and 3051CA measurements.

The major components of the Rosemount 3051 are the sensor module and the electronics housing. The sensor module contains the oil filled sensor system (isolating diaphragms, oil fill system, and sensor) and the sensor electronics. The sensor electronics are installed within the sensor module and include a temperature sensor (RTD), a memory module, and the capacitance to digital signal converter (C/D converter). The electrical signals from the sensor module are transmitted to the output electronics in the electronics housing. The electronics housing contains the output electronics board, the local zero and span buttons, and the terminal block. The basic block diagram of the Rosemount 3051CD is illustrated in Figure 1-1.

For the Rosemount 3051C design pressure is applied to the isolating diaphragms, the oil deflects the center diaphragm, which then changes the capacitance. This capacitance signal is then changed to a digital signal in the C/D converter. The microprocessor then takes the signals from the RTD and C/D converter calculates the correct output of the transmitter. This signal is then sent to the D/A converter, which converts the signal back to an analog signal and superimposes the HART signal on the 4-20 mA output.

Figure 1-1. Block diagram of operation



1.5 Product recycling/ disposal

Recycling of equipment and packaging should be taken into consideration and disposed of in accordance with local and national legislation/regulations.

Section 2 Installation

2.1 Overview

The information in this section covers installation considerations for the Rosemount 3051 with HART protocols. A Quick Installation Guide for HART protocol (document number 00825-0100-4001) is shipped with every transmitter to describe basic pipe-fitting and wiring procedures for initial installation. Dimensional drawings for each 3051 variation and mounting configuration are included on page 13.

2.2 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operation. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 3051 reference manual for any restrictions associated with a safe installation.

- Before connecting a Field Communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

⚠ WARNING

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals.

Process leaks could result in death or serious injury.

- Install and tighten all four flange bolts before applying pressure.
- Do not attempt to loosen or remove flange bolts while the transmitter is in service.

Replacement equipment or spare parts not approved by Emerson Process Management for use as spare parts could reduce the pressure retaining capabilities of the transmitter and may render the instrument dangerous.

- Use only bolts supplied or sold by Emerson Process Management as spare parts.
- Refer to page 164 for a complete list of spare parts.

Improper assembly of manifolds to traditional flange can damage sensor module.

- For safe assembly of manifold to traditional flange, bolts must break back plane of flange web (i.e., bolt hole) but must not contact sensor module housing.

2.3 General considerations

Measurement accuracy depends upon proper installation of the transmitter and impulse piping. Mount the transmitter close to the process and use a minimum of piping to achieve best accuracy. Keep in mind the need for easy access, personnel safety, practical field calibration, and a suitable transmitter environment. Install the transmitter to minimize vibration, shock, and temperature fluctuation.

Important
Install the enclosed pipe plug (found in the box) in unused conduit opening with a minimum of five threads engaged to comply with explosion-proof requirements.

For material compatibility considerations, see document number 00816-0100-3045 on www.emersonprocess.com/rosemount.

2.4 Mechanical considerations

Note
For steam service or for applications with process temperatures greater than the limits of the transmitter, do not blow down impulse piping through the transmitter. Flush lines with the blocking valves closed and refill lines with water before resuming measurement.

Note
When the transmitter is mounted on its side, position the Coplanar flange to ensure proper venting or draining. Mount the flange as shown in Figure 2-8 on page 16, keeping drain/vent connections on the bottom for gas service and on the top for liquid service.

2.5 Draft range considerations

Installation

For the Rosemount 3051CD0 draft range pressure transmitter, it is best to mount the transmitter with the isolators parallel to the ground. Installing the transmitter in this way reduces oil head effect and provides for optimal temperature performance.

Be sure the transmitter is securely mounted. Tilting of the transmitter may cause a zero shift in the transmitter output.

Reducing process noise

There are two recommended methods of reducing process noise: output damping and, in gage applications, reference side filtering.

Output damping

The output damping for the Rosemount 3051CD0 is factory set to 3.2 seconds as a default. If the transmitter output is still noisy, increase the damping time. If faster response is needed, decrease the damping time. Damping adjustment information is available on page 57.

Reference side filtering

In gage applications it is important to minimize fluctuations in atmospheric pressure to which the low side isolator is exposed.

One method of reducing fluctuations in atmospheric pressure is to attach a length of tubing to the reference side of the transmitter to act as a pressure buffer.

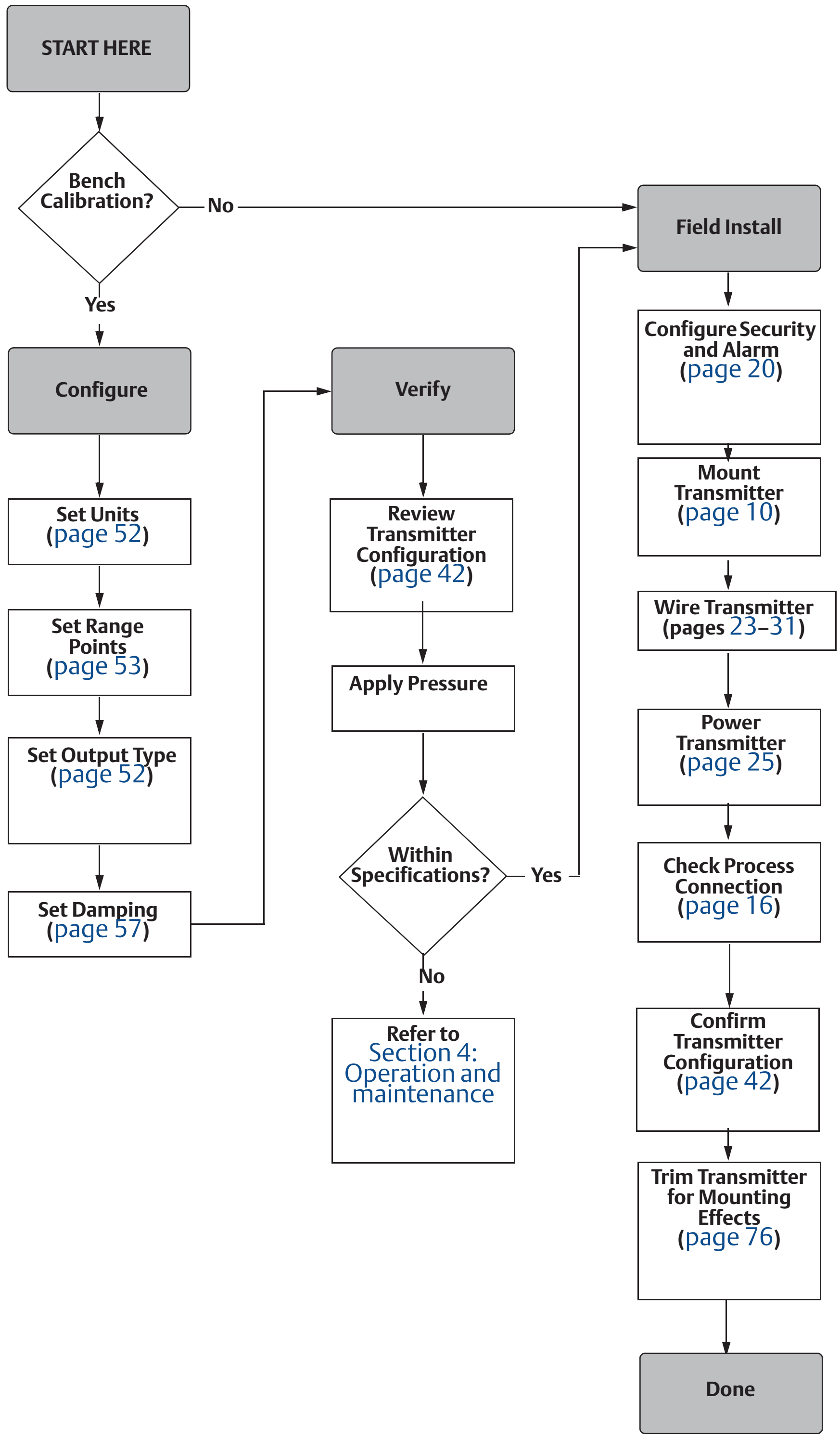
Another method is to plumb the reference side to a chamber that has a small vent to atmosphere. If multiple draft transmitters are being used in an application, the reference side of each device can be plumbed to a chamber to achieve a common gage reference.

2.6 Environmental considerations

Best practice is to mount the transmitter in an environment that has minimal ambient temperature change. The transmitter electronics temperature operating limits are –40 to 185 °F (–40 to 85 °C). Refer to Appendix A: Specifications and reference data that lists the sensing element operating limits. Mount the transmitter so that it is not susceptible to vibration and mechanical shock and does not have external contact with corrosive materials.

2.7 HART installation flowchart

Figure 2-1. HART installation flowchart



2.8 Installation procedures

2.8.1 Mount the transmitter

For dimensional drawing information refer to Appendix A: Specifications and reference data on page 120.

Process flange orientation

Mount the process flanges with sufficient clearance for process connections. For safety reasons, place the drain/vent valves so the process fluid is directed away from possible human contact when the vents are used. In addition, consider the need for a testing or calibration input.

Note
Most transmitters are calibrated in the horizontal position. Mounting the transmitter in any other position will shift the zero point to the equivalent amount of liquid head pressure caused by the varied mounting position. To reset zero point, refer to "Sensor Trim" on page 10.

Housing rotation

See "Housing rotation" on page 18.

Terminal side of electronics housing

Mount the transmitter so the terminal side is accessible. Clearance of 0.75 in. (19 mm) is required for cover removal. Use a conduit plug in the unused conduit opening.

Circuit side of electronics housing

Provide 0.75 in. (19 mm) of clearance for units with out an LCD display. Three inches of clearance is required for cover removal if a meter is installed.

Cover installation

Always ensure a proper seal by installing the electronics housing cover(s) so that metal contacts metal. Use Rosemount O-rings.

Conduit entry threads

For NEMA 4X, IP66, and IP68 requirements, use thread seal (PTFE) tape or paste on male threads to provide a watertight seal.

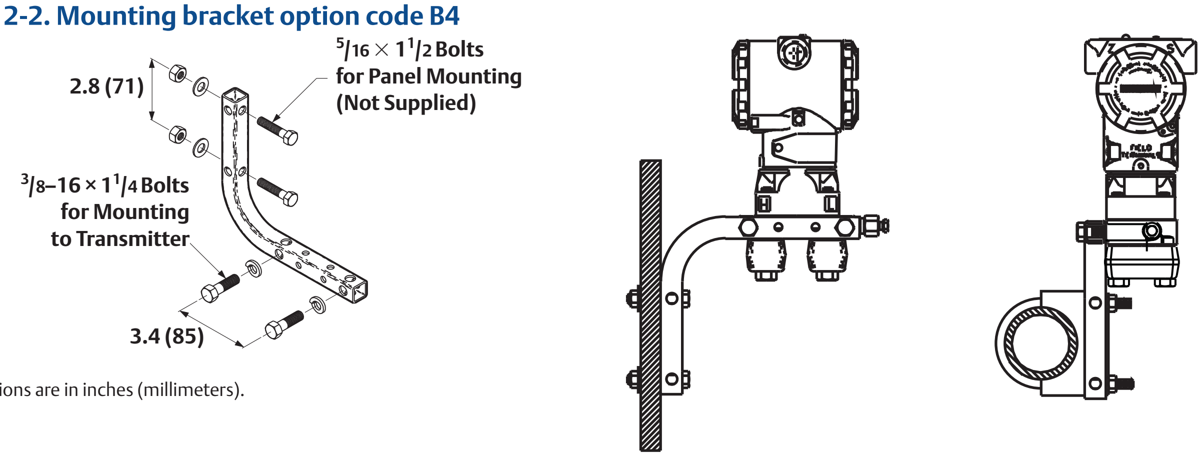
Mounting brackets

Rosemount 3051 Transmitters may be panel-mounted or pipe-mounted through an optional mounting bracket. Refer to Table 2-1 for the complete offering and see Figure 2-2 through Figure 2-5 on pages 11 and 12 for dimensions and mounting configurations.

Table 2-1. Mounting brackets

3051 brackets										
	Process connections			Mounting			Materials			
Option code	Coplanar	In-line	Traditional	Pipe mount	Panel mount	Flat panel mount	CS bracket	SST bracket	CS bolts	SST bolts
B4	X	X		X	X	X		X		X
B1			X	X			X		X	
B2			X		X		X		X	
B3			X			X	X		X	
B7			X	X			X			X
B8			X		X		X			X
B9			X			X	X			X
BA			X	X				X		X
BC			X			X		X		X

Figure 2-2. Mounting bracket option code B4



Note
Dimensions are in inches (millimeters).

Flange bolts

The 3051 can be shipped with a Coplanar flange or a Traditional flange installed with four 1.75-inch flange bolts. Mounting bolts and bolting configurations for the Coplanar and Traditional flanges can be found on page 14. Stainless steel bolts supplied by Emerson Process Management are coated with a lubricant to ease installation. Carbon steel bolts do not require lubrication. No additional lubricant should be applied when installing either type of bolt. Bolts supplied by Emerson Process Management are identified by their head markings:

Figure 2-3. Mounti ng bracket option codes B1, B7, and BA

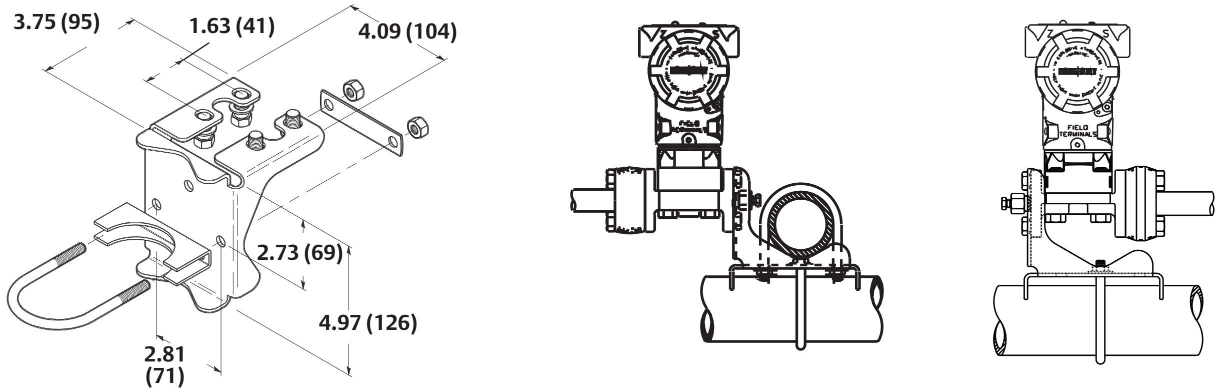


Figure 2-4. Panel mounting bracket option codes B2 and B8

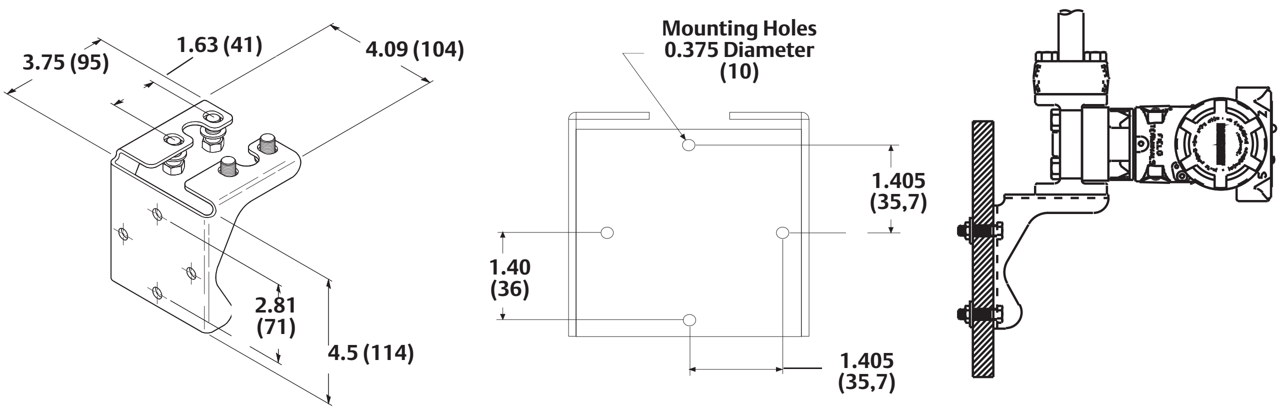
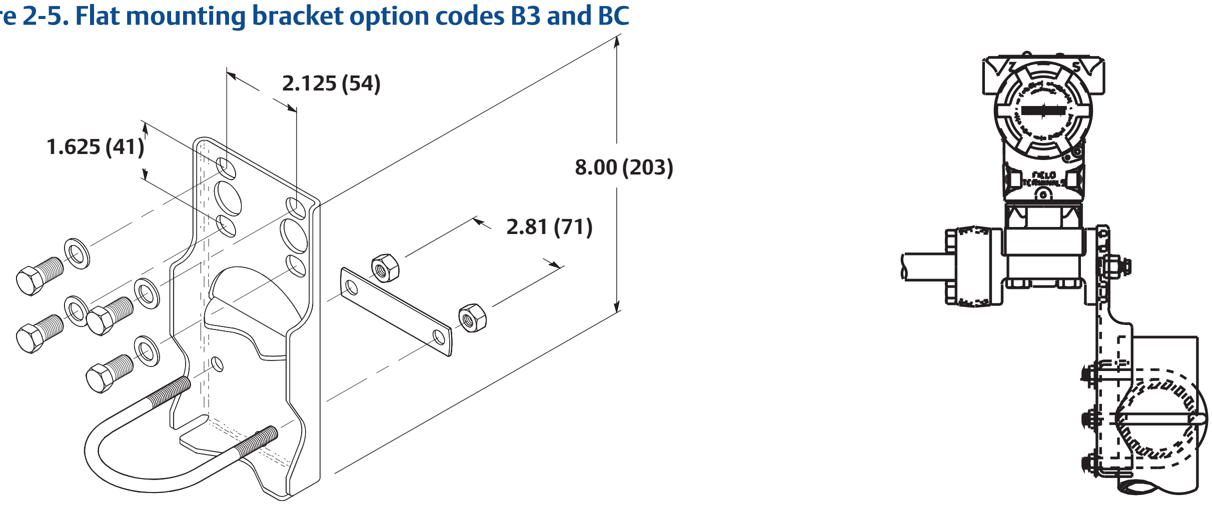
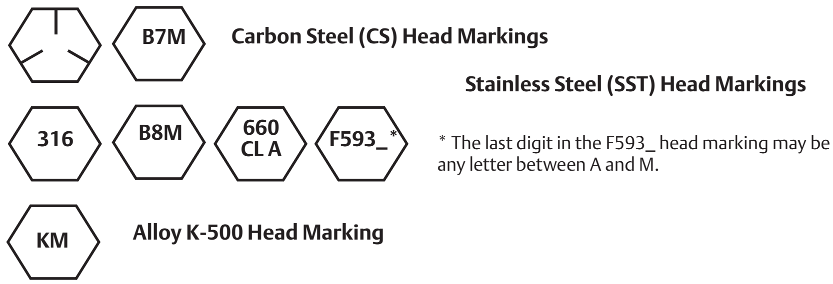


Figure 2-5. Flat mounting bracket option codes B3 and BC



Note
Dimensions are in inches (millimeters).



Bolt installation

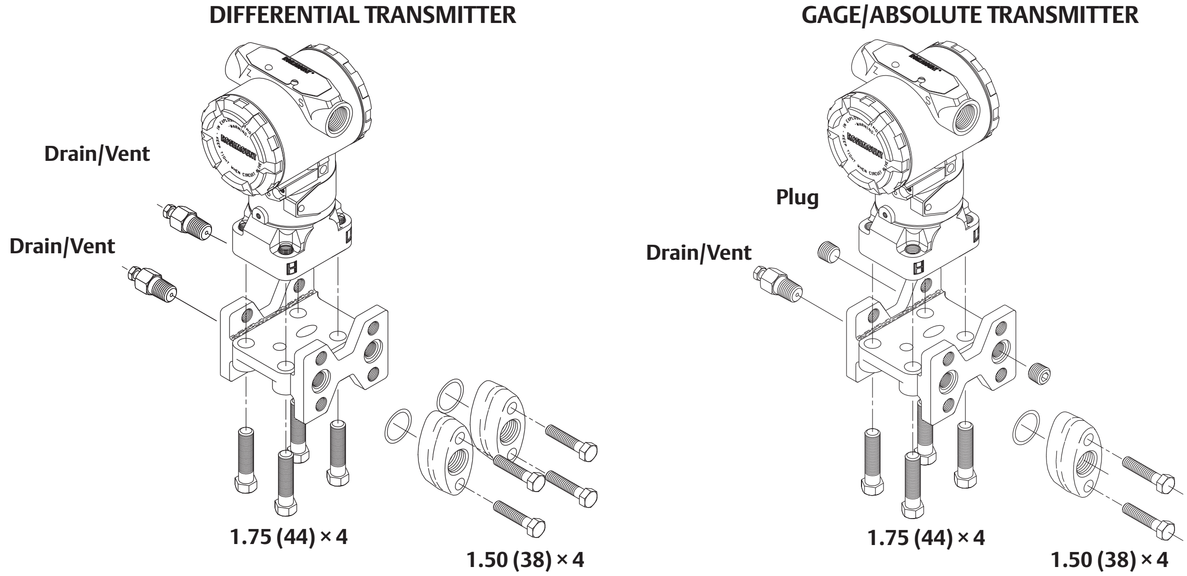
⚠ Only use bolts supplied with the Rosemount 3051 or sold by Emerson Process Management as spare parts for the Rosemount 3051 transmitter. Use the following bolt installation procedure:

1. Finger-tighten the bolts.
2. Torque the bolts to the initial torque value using a crossing pattern (see Table 2-2 for torque values).
3. Torque the bolts to the final torque value using the same crossing pattern.

Table 2-2. Bolt installation torque values

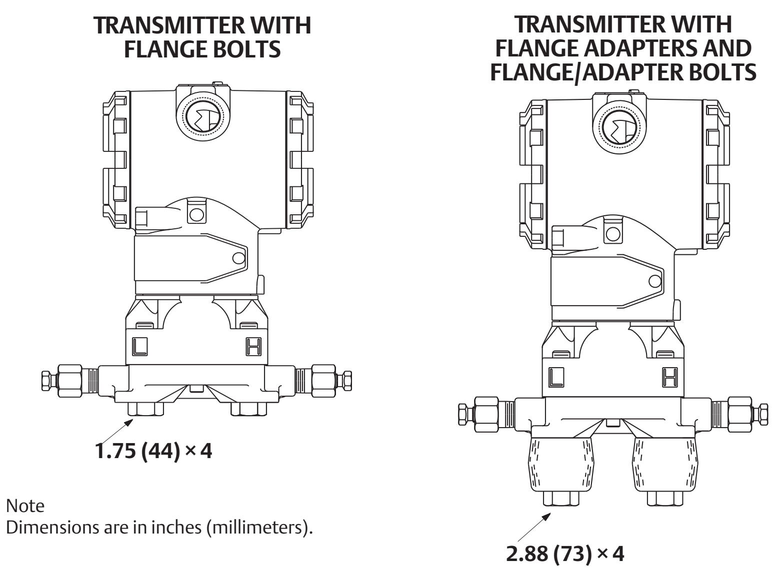
Bolt material	Initial torque value	Final torque value
CS-ASTM-A445 Standard	300 in.-lb (34 N-m)	650 in.-lb (73 N-m)
316 SST—Option L4	150 in.-lb (17 N-m)	300 in.-lb (34 N-m)
ASTM-A-19 B7M—Option L5	300 in.-lb (34 N-m)	650 in.-lb (73 N-m)
Alloy 400—Option L6	300 in.-lb (34 N-m)	650 in.-lb (73 N-m)

Figure 2-4. Traditional flange bolt configurations



Note
Dimensions are in inches (millimeters).

Figure 2-7. Mounting bolts and bolt configurations for coplanar flange



Note
Dimensions are in inches (millimeters).

Description	Qty	Size in. (mm)
Differential Pressure		
Flange Bolts	4	1.75 (44)
Flange/Adapter Bolts	4	2.88 (73)
Gage/Absolute Pressure (1)		
Flange Bolts	4	1.75 (44)
Flange/Adapter Bolts	2	2.88 (73)

(1) Rosemount 3051T transmitters are direct mount and do not require bolts for process connection.

2.8.2 Impulse piping

The piping between the process and the transmitter must accurately transfer the pressure to obtain accurate measurements. There are five possible sources of error: pressure transfer, leaks, friction loss (particularly if purging is used), trapped gas in a liquid line, liquid in a gas line, and density variations between the legs.

The best location for the transmitter in relation to the process pipe is dependent on the process. Use the following guidelines to determine transmitter location and placement of impulse piping:

- Keep impulse piping as short as possible.
- For liquid service, slope the impulse piping at least 1 in./foot (8 cm/m) upward from the transmitter toward the process connection.
- For gas service, slope the impulse piping at least 1 in./foot (8 cm/m) downward from the transmitter toward the process connection.
- Avoid high points in liquid lines and low points in gas lines.
- Make sure both impulse legs are the same temperature.
- Use impulse piping large enough to avoid friction effects and blockage.
- Vent all gas from liquid piping legs.
- When using a sealing fluid, fill both piping legs to the same level.
- When purging, make the purge connection close to the process taps and purge through equal lengths of the same size pipe. Avoid purging through the transmitter.
- Keep corrosive or hot (above 250 °F [121 °C]) process material out of direct contact with the sensor module and flanges.
- Prevent sediment deposits in the impulse piping.
- Maintain equal leg of head pressure on both legs of the impulse piping.
- Avoid conditions that might allow process fluid to freeze within the process flange.

Mounting requirements

Impulse piping configurations depend on specific measurement conditions. Refer to Figure 2-8 for examples of the following mounting configurations:

Liquid flow measurement

- Place taps to the side of the line to prevent sediment deposits on the transmitter's process isolators.
- Mount the transmitter beside or below the taps so gases can vent into the process line.
- Mount drain/vent valve upward to allow gases to vent.

Gas flow measurement

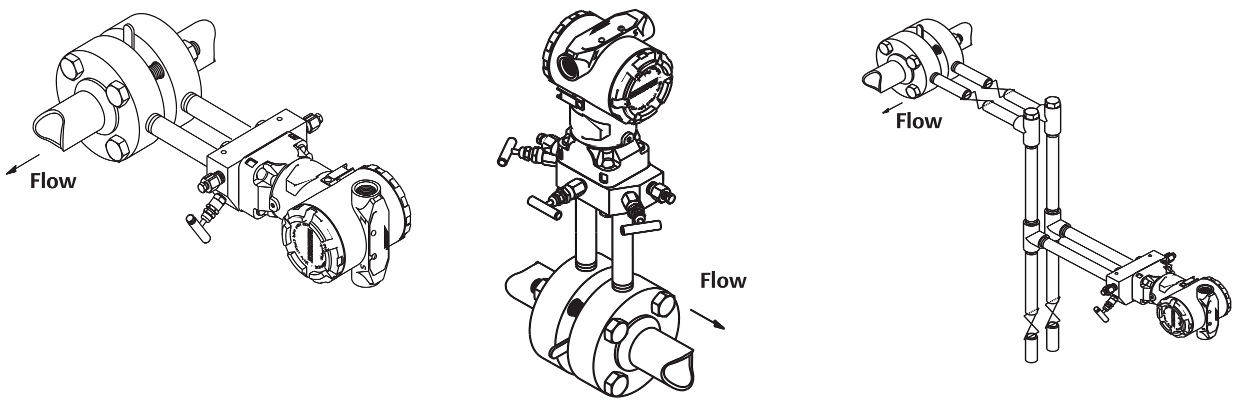
- Place taps in the top or side of the line.
- Mount the transmitter beside or above the taps so liquid will drain into the process line.

Steam flow measurement

- Place taps to the side of the line.
- Mount the transmitter below the taps to ensure that the impulse piping will stay filled with condensate.
- In steam service above 250 °F (121 °C), fill impulse lines with water to prevent steam from contacting the transmitter directly and to ensure accurate measurement start-up.

Note
For steam or other elevated temperature services, it is important that temperatures at the process connection do not exceed the transmitter's process temperature limits.

Figure 2-8. Installation examples



2.8.3 Process connections

Coplanar or traditional process connection

⚠ Install and tighten all four flange bolts before applying pressure, or process leakage will result. When properly installed, the flange bolts will protrude through the top of the sensor module housing. Do not attempt to loosen or remove the flange bolts while the transmitter is in service.

Flange adaptors:

⚠ Rosemount 3051DP and GP process connections on the transmitter flanges are $^1/_4$–18 NPT. Flange adapters are available with standard $^1/_2$–14 NPT Class 2 connections. The flange adapters allow users to disconnect from the process by removing the flange adapter bolts. Use plant-approved lubricant or sealant when making the process connections. Refer to Dimensional Drawings on page 120 for the distance between pressure connections. This distance may be varied $\pm ^1/_8$ in. (3.2 mm) by rotating one or both of the flange adapters.

To install adapters to a Coplanar flange, perform the following procedure:

1. Remove the flange bolts.
2. Leaving the flange in place, move the adapters into position with the o-ring installed.
3. Clamp the adapters and the Coplanar flange to the transmitter sensor module using the larger of the bolts supplied.
4. Tighten the bolts. Refer to "Flange bolts" on page 11 for torque specifications.

Whenever you remove flanges or adapters, visually inspect the PTFE o-rings. Replace with o-ring designed for Rosemount transmitter if there are any signs of damage, such as nicks or cuts. Undamaged o-rings may be reused. If you replace the o-rings, retorque the flange bolts after installation to compensate for cold flow. Refer to the process sensor body reassembly procedure in Section 5: Troubleshooting.

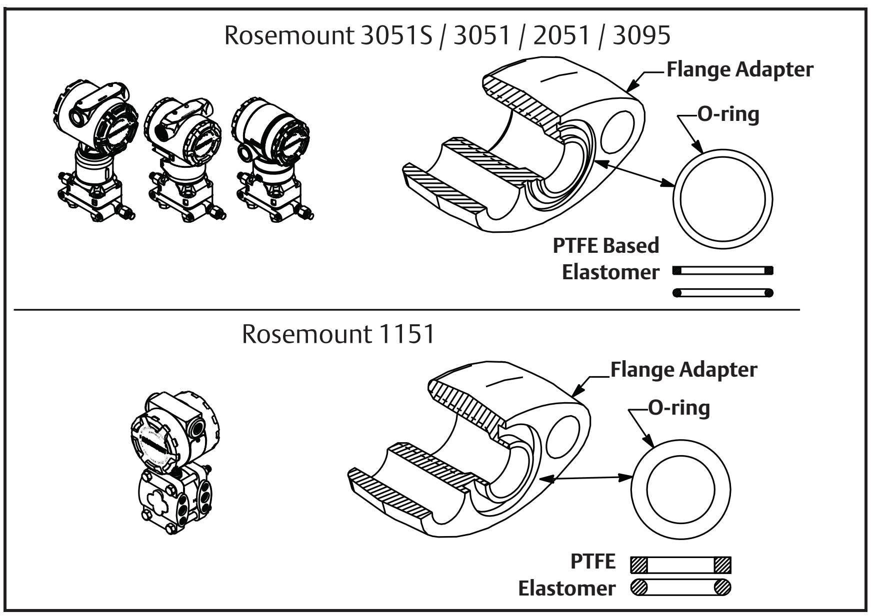
O-rings:

The two styles of Rosemount flange adapters (Rosemount 1151 and Rosemount 3051S/3051/2051/3095) each require a unique O-ring (see Figure 2-9). Use only the O-ring designed for the corresponding flange adaptor.

Figure 2-9. O-Rings.

⚠ WARNING

Failure to install proper flange adapter O-rings may cause process leaks, which can result in death or serious injury. The two flange adapters are distinguished by unique O-ring grooves. Only use the O-ring that is designed for its specific flange adapter, as shown below.



⚠ When compressed, PTFE O-rings tend to “cold flow,” which aids in their sealing capabilities.

Note
PTFE O-rings should be replaced if the flange adapter is removed.

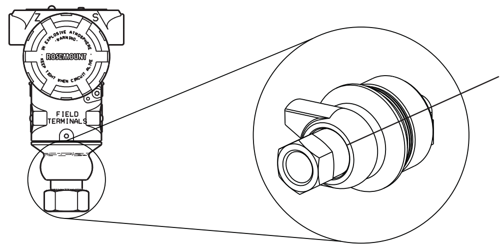
2.8.4 Inline process connection

Inline gage transmitter orientation

The low side pressure port on the inline gage transmitter is located in the neck of the transmitter, behind the housing. The vent path is 360 degrees around the transmitter between the housing and sensor (See Figure 2-10).

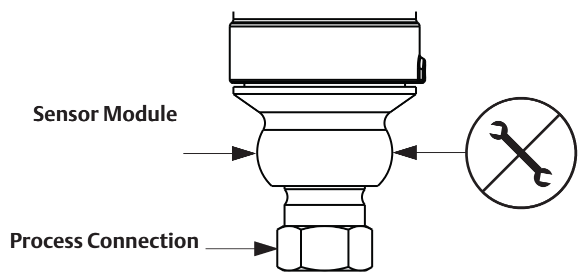
Keep the vent path free of any obstruction, such as paint, dust, and lubrication by mounting the transmitter so that the process can drain away.

Figure 2-10. Inline gage low side pressure port



⚠ WARNING

Do not apply torque directly to the sensor module. Rotation between the sensor module and the process connection can damage the electronics. To avoid damage, apply torque only to the hex-shaped process connection.

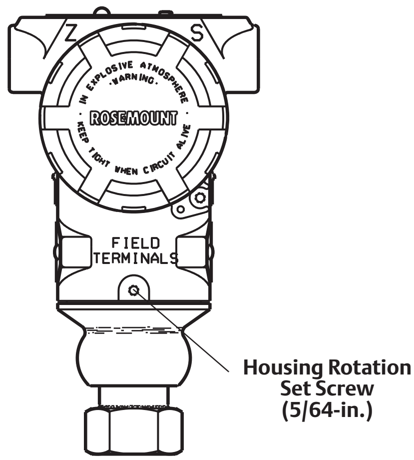


2.8.5 Housing rotation

The electronics housing can be rotated up to 180 degrees in either direction to improve field access, or to better view the optional LCD display. To rotate the housing, perform the following procedure:

1. Loosen the housing rotation set screw using a $\frac{5}{64}$-in. hex wrench.
2. Turn the housing left or right up to 180° from its original position. Over rotating will damage the transmitter.
3. Retighten the housing rotation set screw.

Figure 2-11. Housing rotation



2.8.6 LCD display

Transmitters ordered with the LCD option are shipped with the display installed. Installing the display on an existing 3051 transmitter requires a small instrument screwdriver.

Figure 2-12. LCD display

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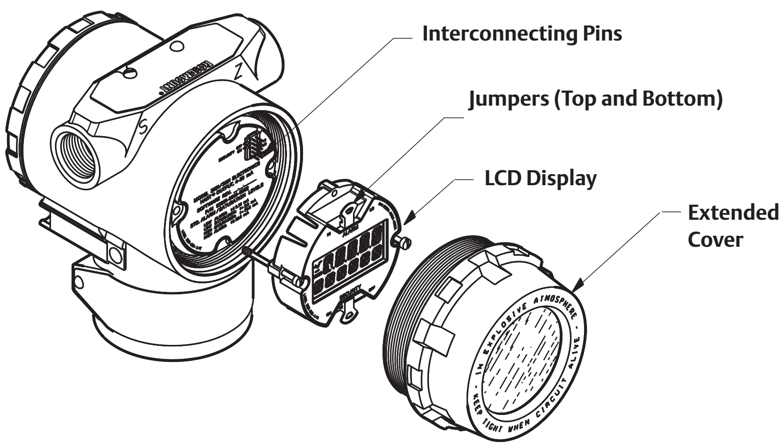


2.8.7 Configure security and alarm

Security (write protect)

There are three security methods with the Rosemount 3051 transmitter:

1. Security Jumper: prevents all writes to transmitter configuration.
2. Local Keys (Local Zero and Span) Software Lock Out: prevents changes to transmitter range points via local zero and span adjustment keys. With local keys security enabled, changes to configuration are possible via HART.
3. Physical Removal of Local Keys (Local Zero and Span) Magnetic Buttons: removes ability to use local keys to make transmitter range point adjustments. With local keys security enabled, changes to configuration are possible via HART.

You can prevent changes to the transmitter configuration data with the write protection jumper. Security is controlled by the security (write protect) jumper located on the electronics board or LCD display. Position the jumper on the transmitter circuit board in the "ON" position to prevent accidental or deliberate change of configuration data.

If the transmitter write protection jumper is in the "ON" position, the transmitter will not accept any "writes" to its memory. Configuration changes, such as digital trim and reranging, cannot take place when the transmitter security is on.

Note
If the security jumper is not installed, the transmitter will continue to operate in the security OFF configuration.

Configuring transmitter security and alarm jumper procedure

To reposition the jumpers, follow the procedure described below.

1. Do not remove the transmitter covers in explosive atmospheres when the circuit is live. If the transmitter is live, set the loop to manual and remove power.
2. ⚠ Remove the housing cover opposite the field terminal side. Do not remove the transmitter covers in explosive atmospheres when the circuit is live.
3. Reposition the jumpers as desired.
   - Figure 2-13 shows the jumper positions for the 4-20 mA HART Transmitter.
   - Figure 2-14 shows the jumper positions for the 1-5 HART Vdc Low Power Transmitter.
4. ⚠ Reattach the transmitter cover. Always ensure a proper seal by installing the electronics housing covers so that metal contacts metal to meet explosion-proof requirements.

Figure 2-13. Electronics board

4-20 mA HART	
Without LCD Meter	**With LCD Display**

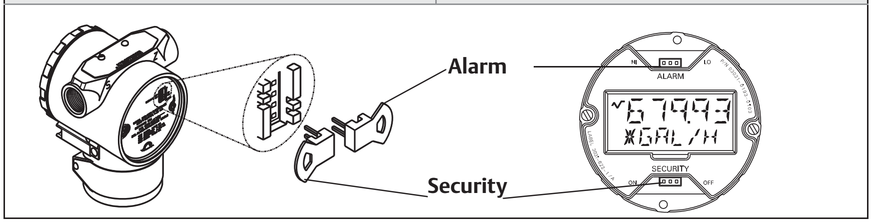
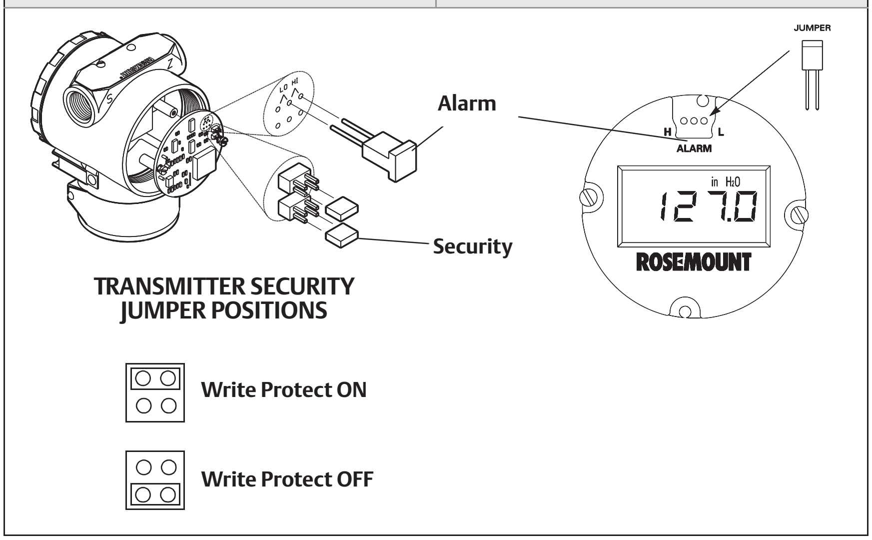


Figure 2-14. Low power transmitter electronics boards

1-5 Vdc HART Low Power	
Without LCD Meter	**With LCD Display**



Note

Security jumper not installed = Not Write Protected
Alarm jumper not installed = High Alarm

2.9 Electrical considerations

Note
Make sure all electrical installation is in accordance with national and local code requirements.

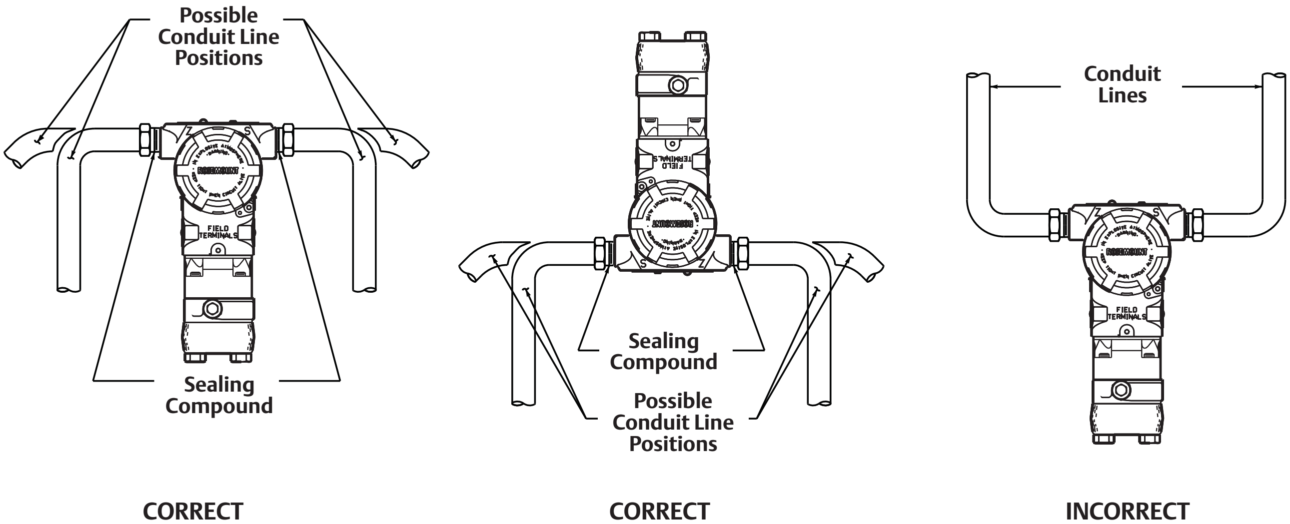
2.9.1 Conduit installation

⚠ CAUTION

If all connections are not sealed, excess moisture accumulation can damage the transmitter. Make sure to mount the transmitter with the electrical housing positioned downward for drainage. To avoid moisture accumulation in the housing, install wiring with a drip loop, and ensure the bottom of the drip loop is mounted lower than the conduit connections or the transmitter housing.

Recommended conduit connections are shown in Figure 2-15.

Figure 2-15. Conduit installation diagrams.



2.9.2 Wiring

⚠ CAUTION

Do not connect the power signal wiring to the test terminals. Voltage may burn out the reverse-polarity protection diode in the test connection.

Note

Use shielded twisted pairs to yield best results. To ensure proper communication, use 24 AWG or larger wire, and do not exceed 5000 feet (1500 meters).

Figure 2-16. 4-20 mA HART wiring

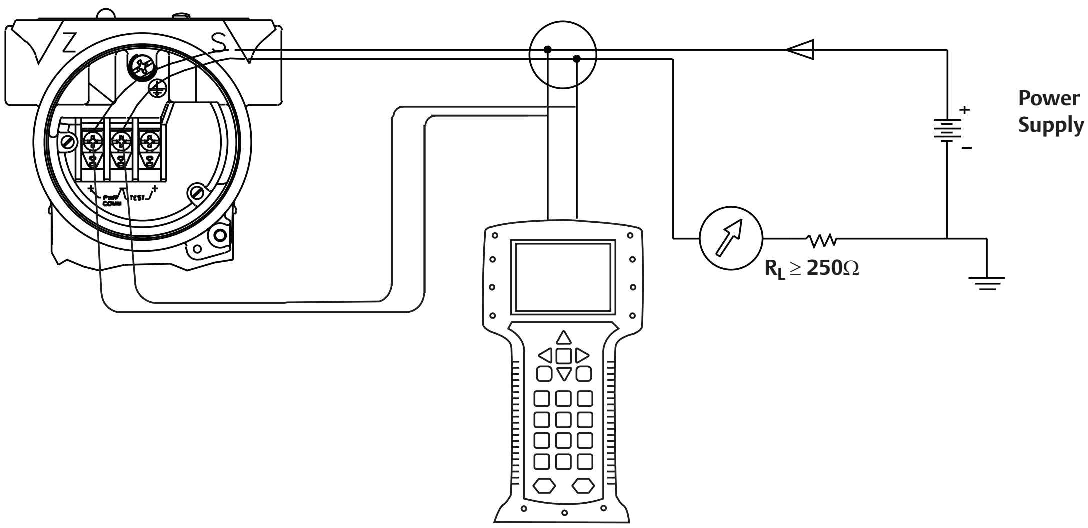
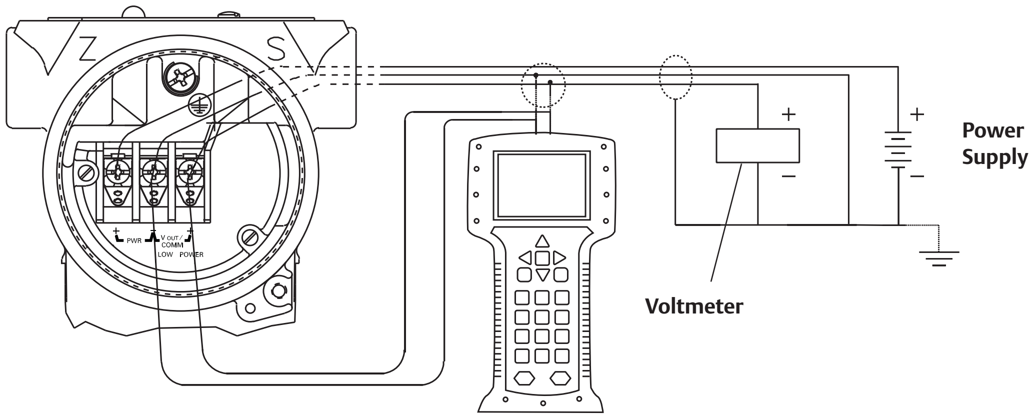


Figure 2-17. 1-5 Vdc low power wiring



Perform the following procedure to make wiring connections:

1. Remove the housing cover on terminal compartment side. Do not remove the cover in explosive atmospheres when the circuit is live. Signal wiring supplies all power to the transmitter.

2. a. For 4-20 mA HART output, connect the positive lead to the terminal marked (+) and the negative lead to the terminal marked (pwr/comm -). Do not connect powered signal wiring to the test terminals. Power could damage the test diode.

   b. For 1-5 Vdc HART Low Power output, connect the positive lead to the terminal marked (+ pwr) and the negative lead to the terminal marked (pwr -). Connect signal lead to V_{out} / comm +.

3. Plug and seal unused conduit connection on the transmitter housing to avoid moisture accumulation in the terminal side. Install wiring with a drip loop. Arrange the drip loop so the bottom is lower than the conduit connections and the transmitter housing.

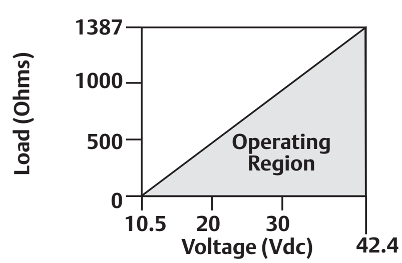
Power supply for 4-20 mA HART

Transmitter operates on 10.5 - 42.4 Vdc. The dc power supply should provide power with less than two percent ripple.

Note
A minimum loop resistance of 250 ohms is required to communicate with a Field Communicator. If a single power supply is used to power more than one 3051 transmitter, the power supply used, and circuitry common to the transmitters, should not have more than 20 ohms of impedance at 1200 Hz.

Figure 2-18. Load limitation

Maximum Loop Resistance = 43.5 * (Power Supply Voltage – 10.5)



The Field Communicator requires a minimum loop resistance of 250Ω for communication.

The total resistance load is the sum of the resistance of the signal leads and the load resistance of the controller, indicator, and related pieces. Note that the resistance of intrinsic safety barriers, if used, must be included.

See "Safety messages" on page 5 for complete warning

Power supply for 1-5 Vdc HART low power

Low power transmitters operate on 6-14 Vdc. The dc power supply should provide power with less than two percent ripple. The V_{out} load should be 100 kΩ or greater.

2.9.3 Transient protection terminal block

The transmitter will withstand electrical transients of the energy level usually encountered in static discharges or induced switching transients. However, high-energy transients, such as those induced in wiring from nearby lightning strikes, can damage the transmitter.

The transient protection terminal block can be ordered as an installed option (Option Code T1 in the transmitter model number) or as a spare part to retrofit existing 3051 transmitters in the field. See "Spare parts" on page 164 for spare part numbers. The lightning bolt symbol shown in Figure 2-19 and Figure 2-20 identifies the transient protection terminal block.

Figure 2-19. 4-20 mA HART wiring with transient protection

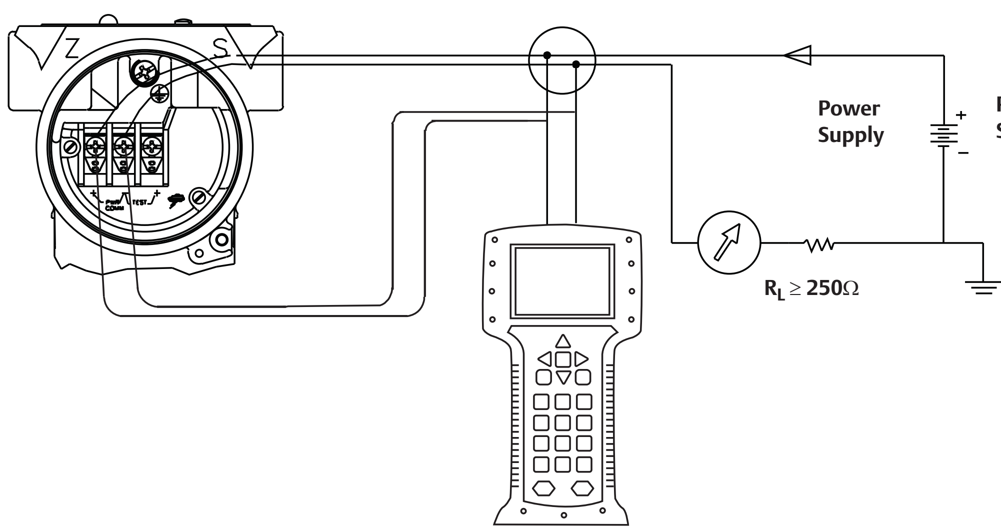


Figure 2-20. 1-5 Vdc low power wiring with transient protection

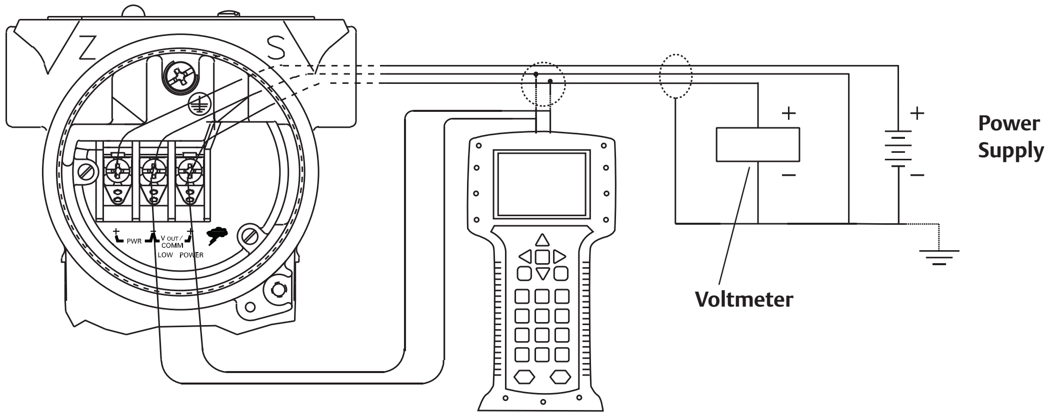
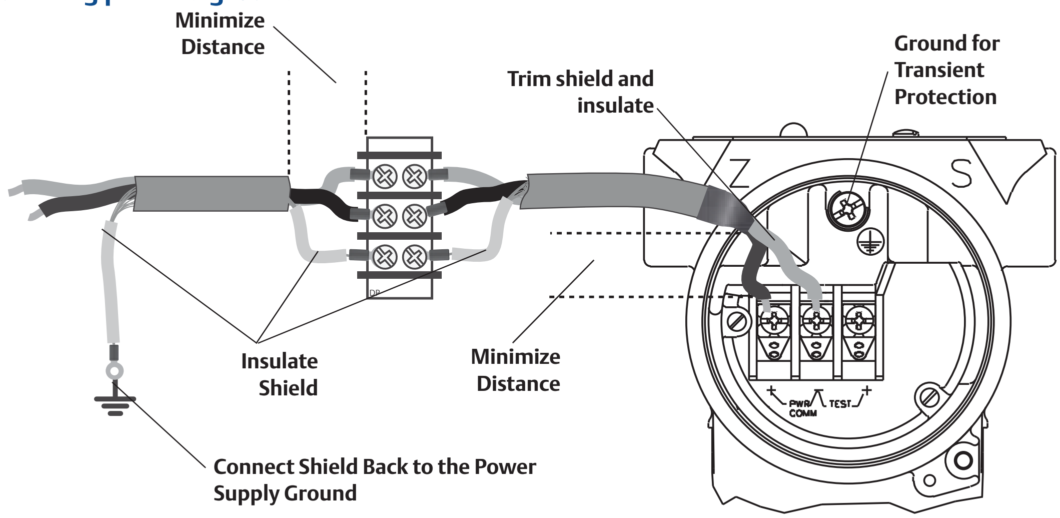


Figure 2-21. Wiring pair and ground



Note

The transient protection terminal block does not provide transient protection unless the transmitter case is properly grounded. Use the guidelines to ground the transmitter case. Refer to page 27.

Do not run the transient protection ground wire with signal wiring as the ground wire may carry excessive current if a lightning strike occurs.

2.9.4 Grounding

⚠ Use the following techniques to properly ground the transmitter signal wiring and case:

Signal wiring

Do not run signal wiring in conduit or open trays with power wiring or near heavy electrical equipment. It is important that the instrument cable shield be:

- Trimmed close and insulated from touching the transmitter housing
- Connected to the next shield if cable is routed through a junction box
- Connected to a good earth ground at the power supply end

For 4-20 mA HART output, the signal wiring may be grounded at any one point on the signal loop or may be left ungrounded. The negative terminal of the power supply is a recommended grounding point.

For 1-5 Vdc HART Low Power output, the power wires may be grounded at only one point or left ungrounded. The negative terminal of the power supply is a recommended grounding point.

Transmitter case

Always ground the transmitter case in accordance with national and local electrical codes. The most effective transmitter case grounding method is a direct connection to earth ground with minimal impedance. Methods for grounding the transmitter case include:

- Internal Ground Connection: The Internal Ground Connection screw is inside the FIELD TERMINALS side of the electronics housing. This screw is identified by a ground symbol (⏚). The ground connection screw is standard on all Rosemount 3051 transmitters. Refer to Figure 2-22.

Figure 2-22. Internal ground screw

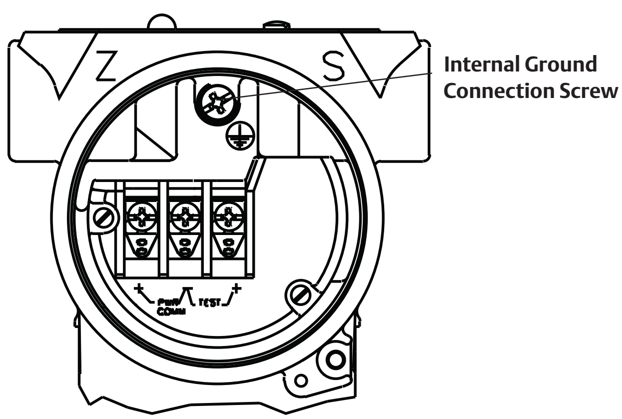
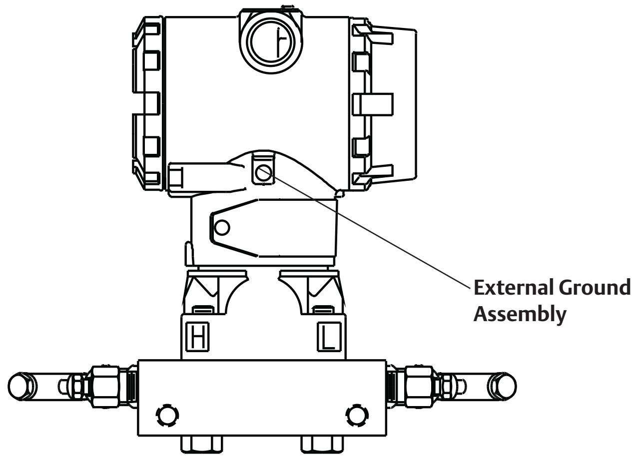


Figure 2-23. External ground assembly



Note

Grounding the transmitter case via threaded conduit connection may not provide sufficient ground continuity.

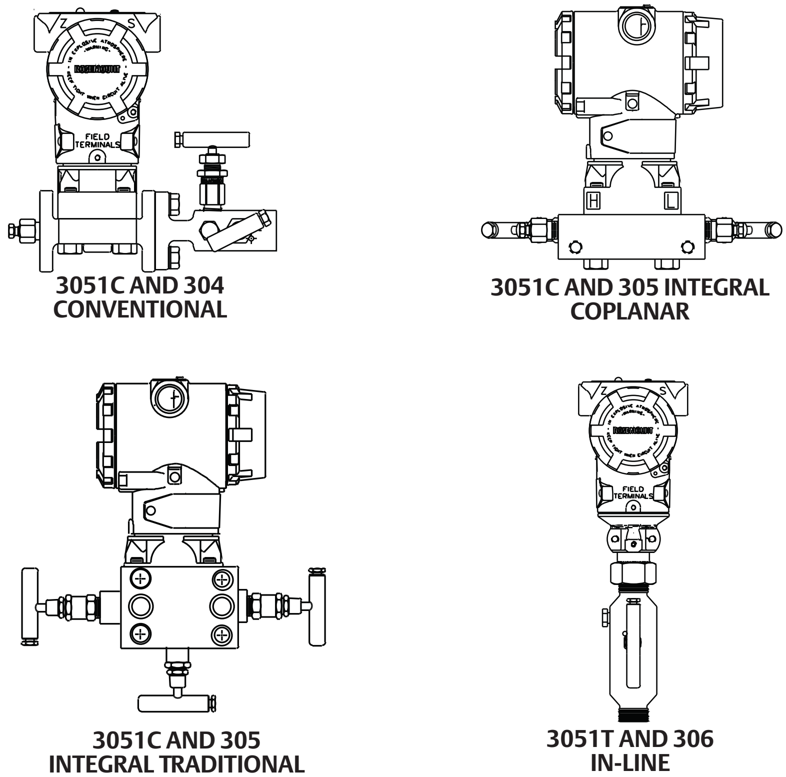
2.10 Hazardous locations certifications

⚠ Individual transmitters are clearly marked with a tag indicating the approvals they carry. Transmitters must be installed in accordance with all applicable codes and standards to maintain these certified ratings. Refer to "Hazardous locations certifications" on page 177 for information on these approvals.

2.11 Rosemount 305, 306, and 304 manifolds

The 305 Integral Manifold is available in two designs: Traditional and Coplanar. The traditional 305 Integral Manifold can be mounted to most primary elements with mounting adapters in the market today. The 306 Integral Manifold is used with the 3051T in-line transmitters to provide block-and-bleed valve capabilities of up to 10000 psi (690 bar).

Figure 2-24. Manifolds



2.11.1 Rosemount 305 integral manifold installation procedure

To install a 305 Integral Manifold to a 3051 transmitter:

⚠ 1. Inspect the PTFE sensor module o-rings. Undamaged o-rings may be reused. If the o-rings are damaged (if they have nicks or cuts, for example), replace with o-rings designed for Rosemount transmitter.

Important
If replacing the o-rings, take care not to scratch or deface the o-ring grooves or the surface of the isolating diaphragm while you remove the damaged o-rings.

2. Install the Integral Manifold on the sensor module. Use the four 2.25-in. manifold bolts for alignment. Finger tighten the bolts, then tighten the bolts incrementally in a cross pattern to final torque value. See "Flange bolts" on page 11 for complete bolt installation information and torque values. When fully tightened, the bolts should extend through the top of the sensor module housing.

3. If the PTFE sensor module o-rings have been replaced, the flange bolts should be re-tightened after installation to compensate for cold flow of the o-rings.

Note
Always perform a zero trim on the transmitter/manifold assembly after installation to eliminate mounting effects.

2.11.2 Rosemount 306 integral manifold installation procedure

The 306 Manifold is for use only with a 3051T In-line transmitter.

⚠ Assemble the 306 Manifold to the 3051T In-line transmitter with a thread sealant.

2.11.3 Rosemount 304 conventional manifold installation procedure

To install a 304 Conventional Manifold to a 3051 transmitter:

1. Align the Conventional Manifold with the transmitter flange. Use the four manifold bolts for alignment.

2. Finger tighten the bolts, then tighten the bolts incrementally in a cross pattern to final torque value. See "Flange bolts" on page 11 for complete bolt installation information and torque values. When fully tightened, the bolts should extend through the top of the sensor module housing.

3. Leak-check assembly to maximum pressure range of transmitter.

2.11.4 Manifold operation

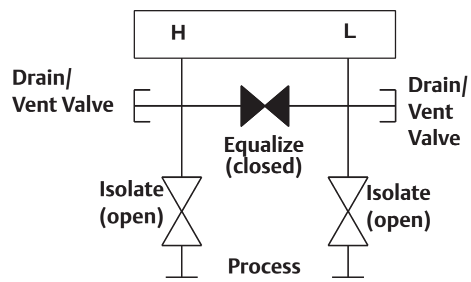
⚠ Improper installation or operation of manifolds may result in process leaks, which may cause death or serious injury.

⚠ See "Safety messages" on page 5 for complete warning information.

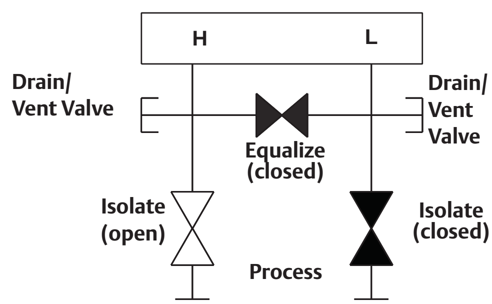
Always perform a zero trim on the transmitter/manifold assembly after installation to eliminate any shift due to mounting effects. See “Sensor Trim Overview” on page 10.

Three and five-valve configurations shown:

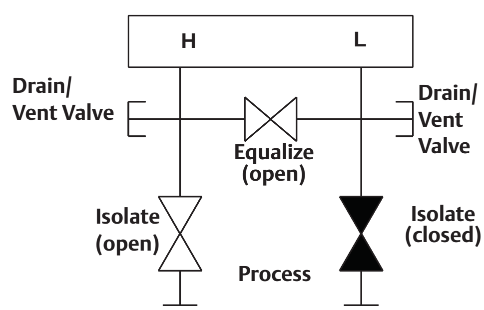
In normal operation the two block valves between the process and instrument ports will be open and the equalizing valve will be closed.



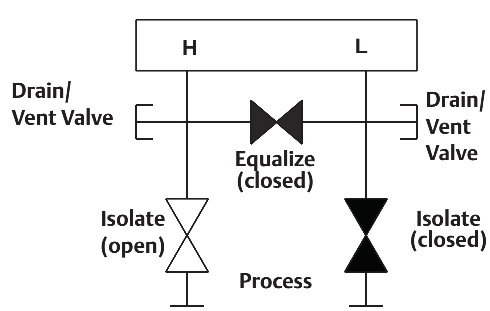
1. To zero the 3051, close the block valve to the low pressure (downstream) side of the transmitter first.



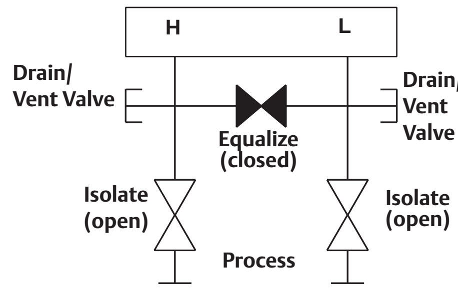
2. Open the center (equalize) valve to equalize the pressure on both sides of the transmitter. The manifold valves are now in the proper configuration for zeroing the transmitter.



3. After zeroing the transmitter, close the equalizing valve.

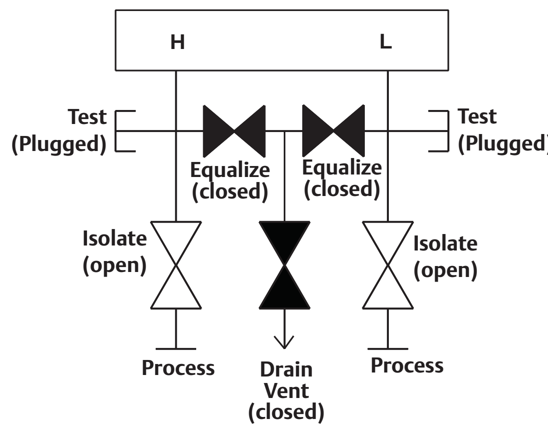


4. Open the block valve on the low pressure side of the transmitter to return the transmitter to service.

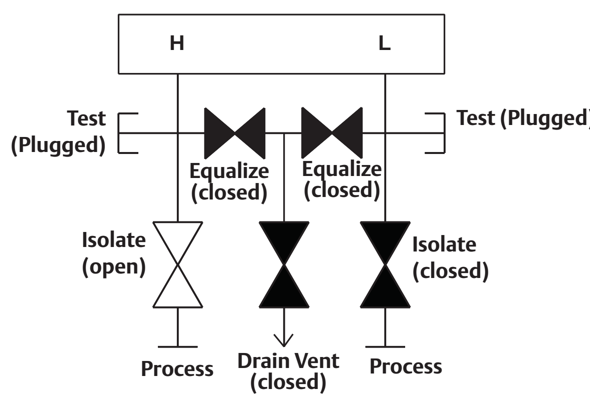


Five-valve Natural Gas configurations shown:

In normal operation, the two block valves between the process and instrument ports will be open, and the equalizing valves will be closed.

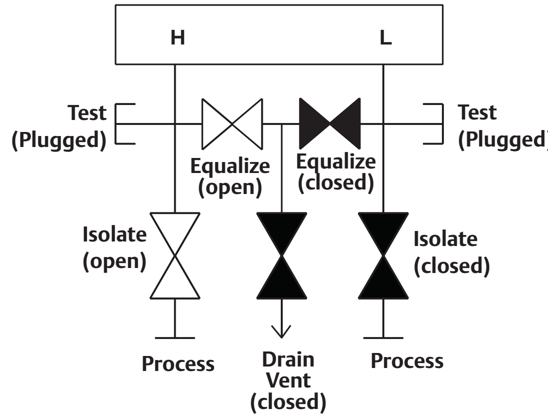


1. To zero the 3051, first close the block valve on the low pressure (downstream) side of the transmitter.

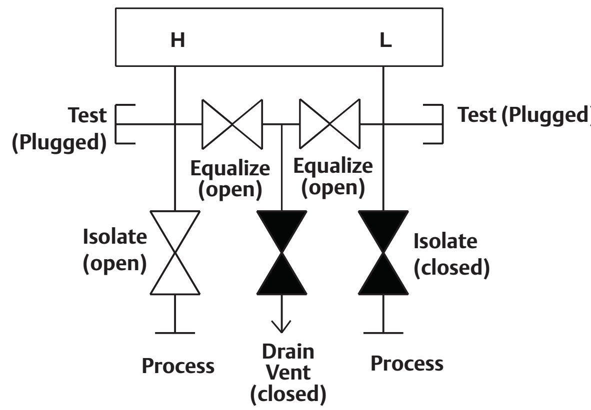


Note
Do not open the low side equalize valve before the high side equalize valve. Doing so will overpressure the transmitter.

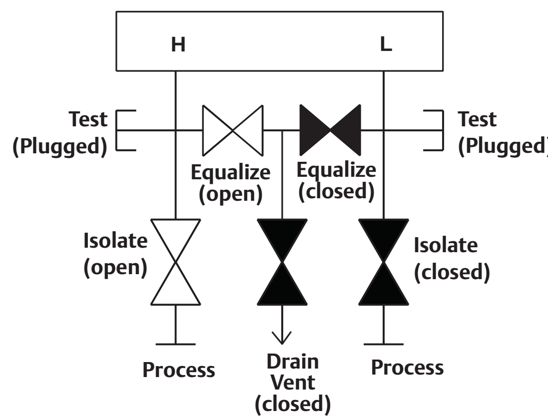
2. Open the equalize valve on the high pressure (upstream) side of the transmitter.



3. Open the equalize valve on the low pressure (downstream) side of the transmitter. The manifold is now in the proper configuration for zeroing the transmitter.



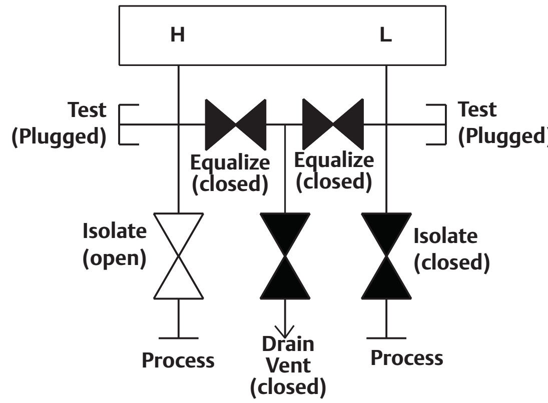
4. After zeroing the transmitter, close the equalize valve on the low pressure (downstream) side of the transmitter.



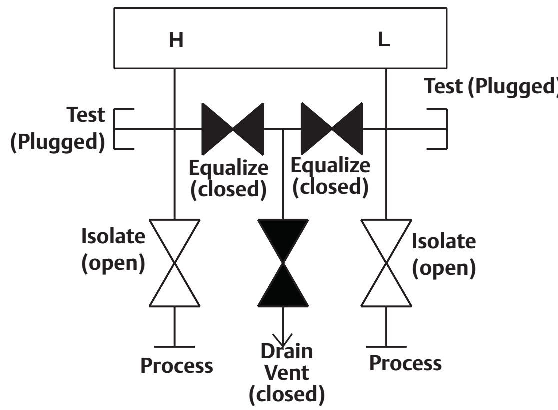
2.12 Liquid level measurement

Differential pressure transmitters used for liquid level applications measure hydrostatic pressure head. Liquid level and specific gravity of a liquid are factors in determining pressure head. This pressure is equal to the liquid height above the tap multiplied by the specific gravity of the liquid. Pressure head is independent of volume or vessel shape.

5. Close the equalize valve on the high pressure (upstream) side.



6. Finally, to return the transmitter to service, open the low side isolation valve.



2.12.1 Open vessels

A pressure transmitter mounted near a tank bottom measures the pressure of the liquid above.

Make a connection to the high pressure side of the transmitter, and vent the low pressure side to the atmosphere. Pressure head equals the liquid's specific gravity multiplied by the liquid height above the tap.

Zero range suppression is required if the transmitter lies below the zero point of the desired level range. Figure 2-25 shows a liquid level measurement example.

2.12.2 Closed vessels

Pressure above a liquid affects the pressure measured at the bottom of a closed vessel. The liquid specific gravity multiplied by the liquid height plus the vessel pressure equals the pressure at the bottom of the vessel.

To measure true level, the vessel pressure must be subtracted from the vessel bottom pressure. To do this, make a pressure tap at the top of the vessel and connect this to the low side of the transmitter. Vessel pressure is then equally applied to both the high and low sides of the transmitter. The resulting differential pressure is proportional to liquid height multiplied by the liquid specific gravity.

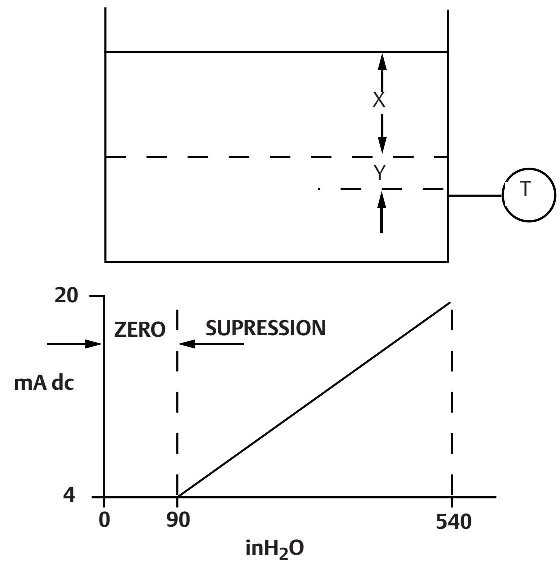
Dry leg condition

Low-side transmitter piping will remain empty if gas above the liquid does not condense. This is a dry leg condition. Range determination calculations are the same as those described for bottom-mounted transmitters in open vessels, as shown in Figure 2-25.

Figure 2-25. Liquid level measurement example.

Let X equal the vertical distance between the minimum and maximum measurable levels (500 in.).
Let Y equal the vertical distance between the transmitter datum line and the minimum measurable level (100 in.).
Let SG equal the specific gravity of the fluid (0.9).
Let h equal the maximum head pressure to be measured in inches of water.
Let e equal head pressure produced by Y expressed in inches of water.
Let Range equal e to e + h.

Then	h	=	(X)(SG)
		=	500 x 0.9
		=	450 inH_2O
	e	=	(Y)(SG)
		=	100 x 0.9
		=	90 inH_2O
Range		=	90 to 540 inH_2O



Wet leg condition

Condensation of the gas above the liquid slowly causes the low side of the transmitter piping to fill with liquid. The pipe is purposely filled with a convenient reference fluid to eliminate this potential error. This is a wet leg condition.

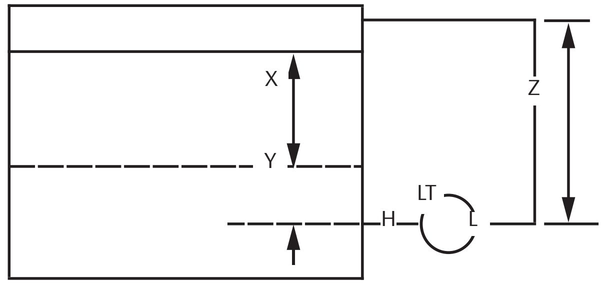
The reference fluid will exert a head pressure on the low side of the transmitter. Zero elevation of the range must then be made. See Figure 2-26.

Bubbler system in open vessel

A bubbler system that has a top-mounted pressure transmitter can be used in open vessels. This system consists of an air supply, pressure regulator, constant flow meter, pressure transmitter, and a tube that extends down into the vessel.

Bubble air through the tube at a constant flow rate. The pressure required to maintain flow equals the liquid's specific gravity multiplied by the vertical height of the liquid above the tube opening. Figure 2-27 shows a bubbler liquid level measurement example.

Figure 2-26. Wet leg example.



Let X equal the vertical distance between the minimum and maximum measurable levels (500 in.).
Let Y equal the vertical distance between the transmitter datum line and the minimum measurable level (50 in.).
Let z equal the vertical distance between the top of the liquid in the wet leg and the transmitter datum line (600 in.).
Let SG_1 equal the specific gravity of the fluid (1.0).
Let SG_2 equal the specific gravity of the fluid in the wet leg (1.1).
Let h equal the maximum head pressure to be measured in inches of water.
Let e equal the head pressure produced by Y expressed in inches of water.
Let s equal head pressure produced by z expressed in inches of water.
Let Range equal e – s to h + e – s.

Then h = $(X)(SG_1)$
= 500 x 1.0
= 500 in H_2O
e = $(Y)(SG_1)$
= 50 x 1.0
= 50 inH_2O
s = $(z)(SG_2)$
= 600 x 1.1
= 660 inH_20
Range = e – s to h + e – s.
= 50 – 660 to 500 + 50 – 660
= –610 to –110 inH_20

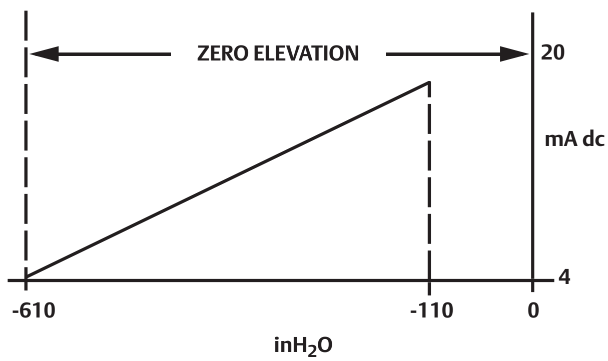
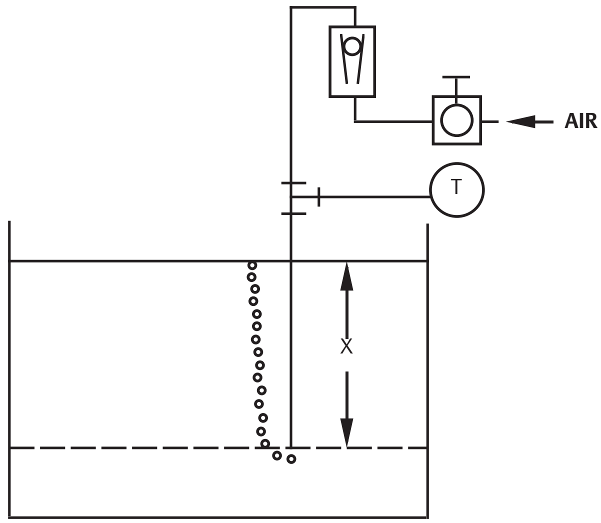


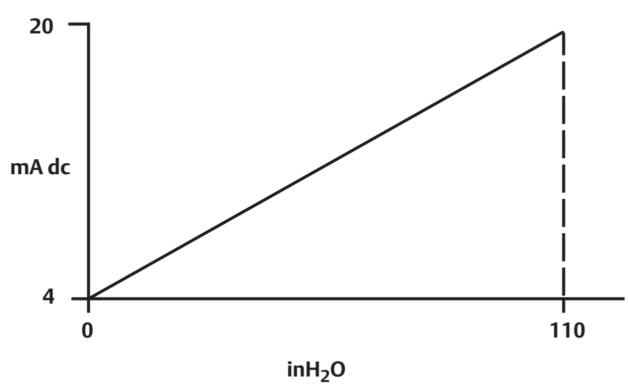
Figure 2-27. Bubbler liquid level measurement example.



Let X equal the vertical distance between the minimum and maximum measurable levels (100 in.).
Let SG equal the specific gravity of the fluid (1.1).
Let h equal the maximum head pressure to be measured in inches of water.
Let Range equal zero to h.

Then h = (X)(SG)
= 100 x 1.1
= 110 inH_2O

Range = 0 to 110 inH_2O



Section 3 Configuration

3.1 Overview

This section contains information on commissioning and tasks that should be performed on the bench prior to installation.

Field Communicator and AMS Device Manager instructions are given to perform configuration functions. For convenience, Field Communicator fast key sequences are labeled “Fast Keys” for each software function below the appropriate headings.

3.2 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 3051 reference manual for any restrictions associated with a safe installation.

- Before connecting a Field Communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an explosion-proof/flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

3.3 Commissioning

Commissioning consists of testing the transmitter and verifying transmitter configuration data. The 3051 transmitters can be commissioned either before or after installation. Commissioning the transmitter on the bench before installation using a Field Communicator or AMS Device Manager ensures that all transmitter components are in working order.

⚠ To commission on the bench, required equipment includes a power supply, a milliamp meter, and a Field Communicator or AMS Device Manager. Wire equipment as shown in Figure 3-1 and Figure 3-2. To ensure successful communication, a resistance of at least 250 ohms must be present between the Field Communicator loop connection and the power supply. Connect the Field Communicator leads to the terminals labeled “COMM” on the terminal block.

Set all transmitter hardware adjustments during commissioning to avoid exposing the transmitter electronics to the plant environment after installation.

When using a Field Communicator, any configuration changes made must be sent to the transmitter by using the Send key. AMS Device Manager configuration changes are implemented when the Apply button is clicked.

3.3.1 Setting the loop to manual

Whenever sending or requesting data that would disrupt the loop or change the output of the transmitter, set the process application loop to manual. The Field Communicator or AMS Device Manager will prompt you to set the loop to manual when necessary. Acknowledging this prompt does not set the loop to manual. The prompt is only a reminder; set the loop to manual as a separate operation.

3.3.2 Wiring diagrams

Connect the equipment as shown in Figure 3-1 for 4-20 mA HART or Figure 3-2 for 1-5 Vdc HART Low Power. To ensure successful communication, a resistance of at least 250 ohms must be present between the Field Communicator loop connection and the power supply. The Field Communicator or AMS Device Manager may be connected at “COMM” on the transmitter terminal block or across the load resistor. Connecting across the “TEST” terminals will prevent successful communication for 4-20 mA HART output.

Turn on the Field Communicator by pressing the ON/OFF key or log into AMS Device Manager. The Field Communicator or AMS Device Manager will search for a HART-compatible device and indicate when the connection is made. If the Field Communicator or AMS Device Manager fail to connect, it indicates that no device was found. If this occurs, refer to Section 5: Troubleshooting.

Figure 3-1. Wiring (4–20 mA)

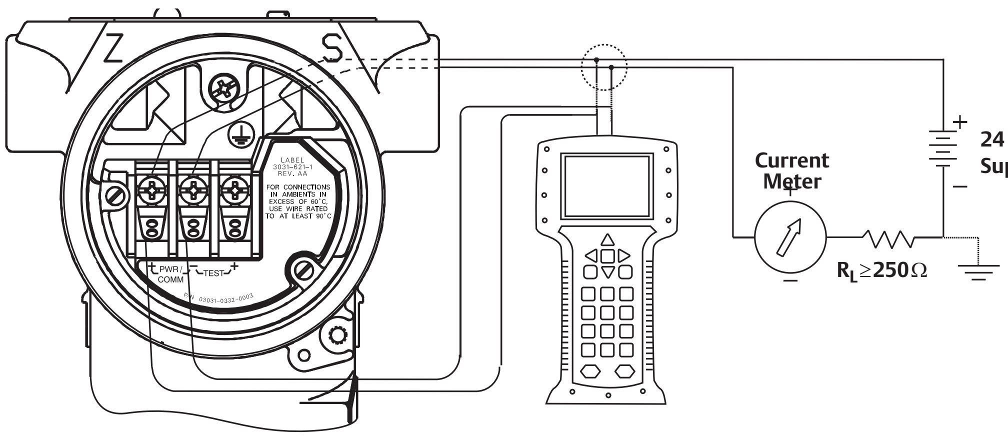
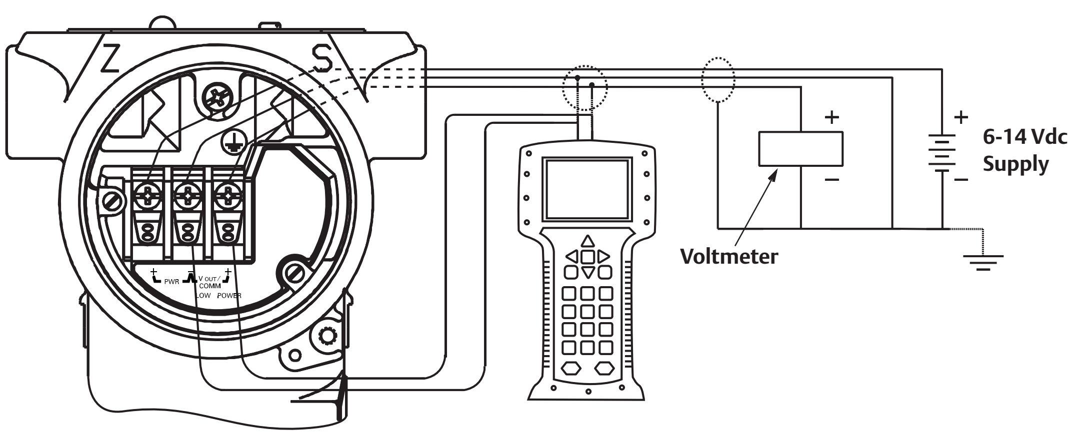


Figure 3-2. Wiring (Low-Power)



3.4 Configuration data review

Note
Information and procedures in this section that make use of Field Communicator fast key sequences and AMS Device Manager assume that the transmitter and communication equipment are connected, powered, and operating correctly.

The following is a list of factory default configurations. These can be reviewed by using the Field Communicator or AMS Device Manager.

Field communicator

Traditional 4-20 mA Fast Keys	1, 5
Traditional 1-5 Vdc Fast Keys	1, 5
Device Dashboard Fast Keys	1, 7

Enter the fast key sequence to view the configuration data.

Transmitter Model	Type
Tag	Range
Date	Descriptor
Message	Minimum and Maximum Sensor Limits
Minimum Span	Units
4 and 20 mA points	Output (linear or sq. root)
Damping	Alarm Setting (high, low)
Security Setting (on, off)	Local Zero/Span Keys (enabled, disabled)
Integral Display	Sensor Fill
Isolator Material	Flange (type, material)
O-Ring Material	Drain/Vent
Remote Seal (type, fill fluid, isolator material, number)	Transmitter S/N
Address	Sensor S/N

AMS device manager

Right click on the device and select Configuration Properties from the menu. Select the tabs to review the transmitter configuration data.

3.5 Field communicator

(Version 1.8)

3.5.1 Field communicator user interface

Figure 3-3. Traditional interface

The corresponding Menu Trees can be viewed on page 44 and page 45.

The fast key sequence can be viewed on page 48.

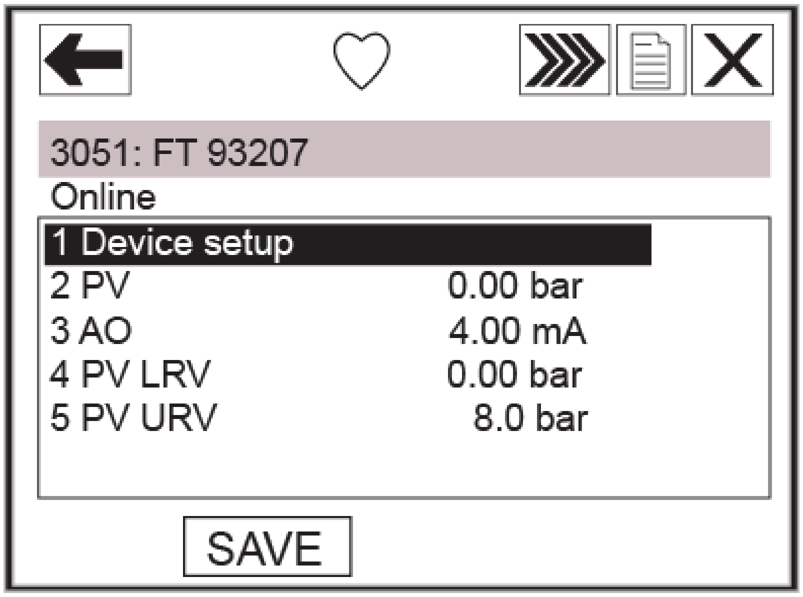
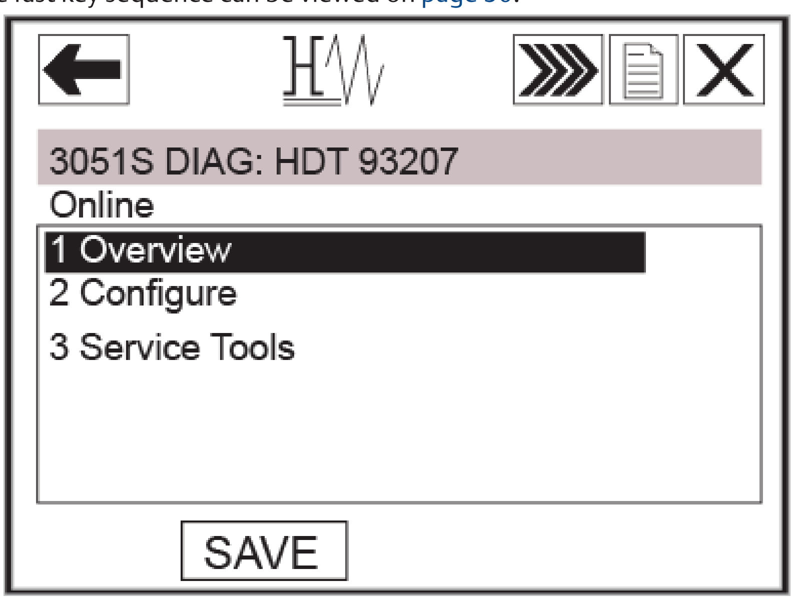


Figure 3-4. Device dashboard

The corresponding Menu Trees can be viewed on page 46 through page 48.

The fast key sequence can be viewed on page 50.



3.6 Field communicator menu trees

Figure 3-5. Rosemount 3051 traditional HART menu tree for 4-20 mA HART output

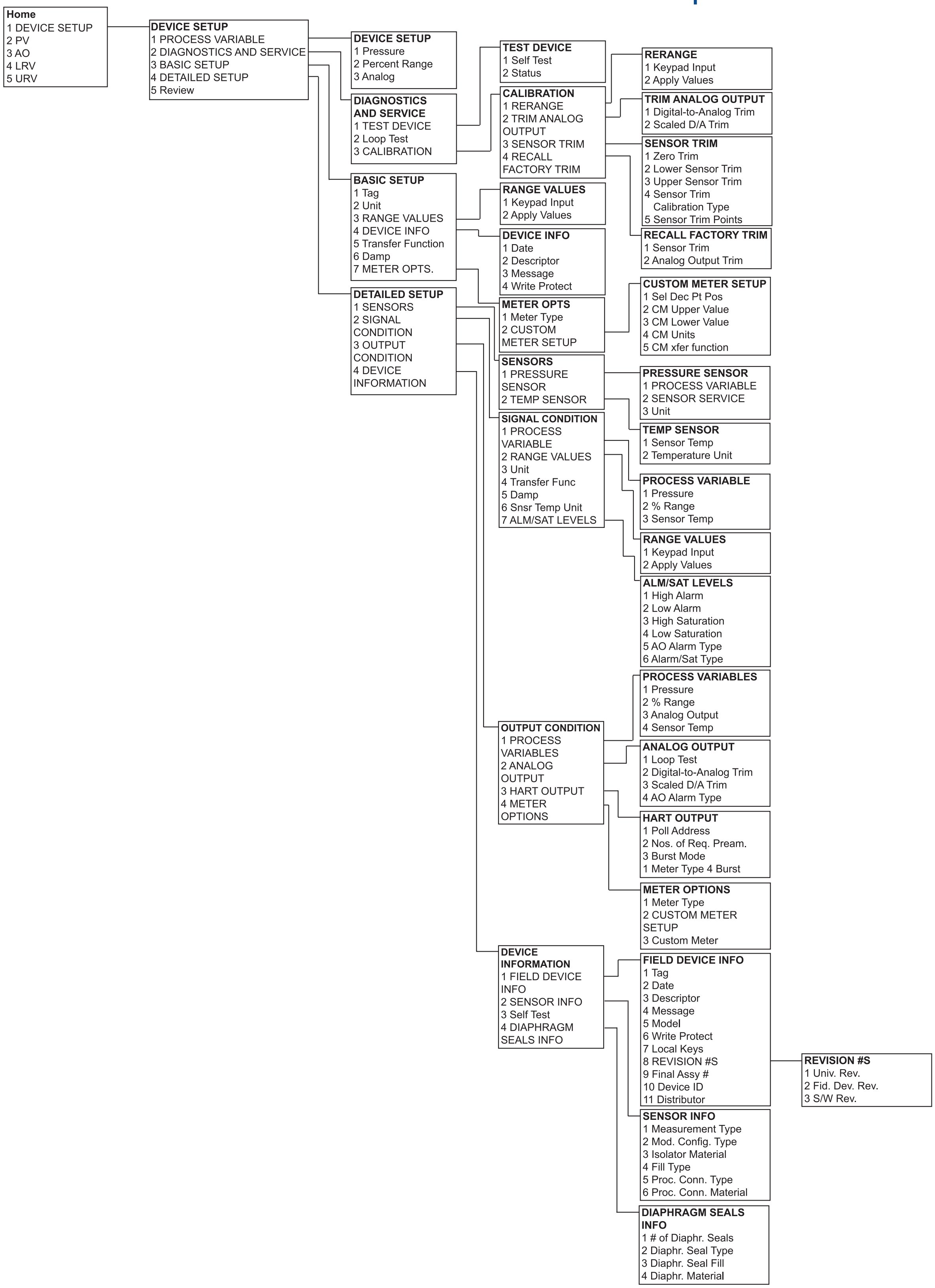


Figure 3-6. Rosemount 3051 traditional HART menu tree for 1-5 Vdc low power

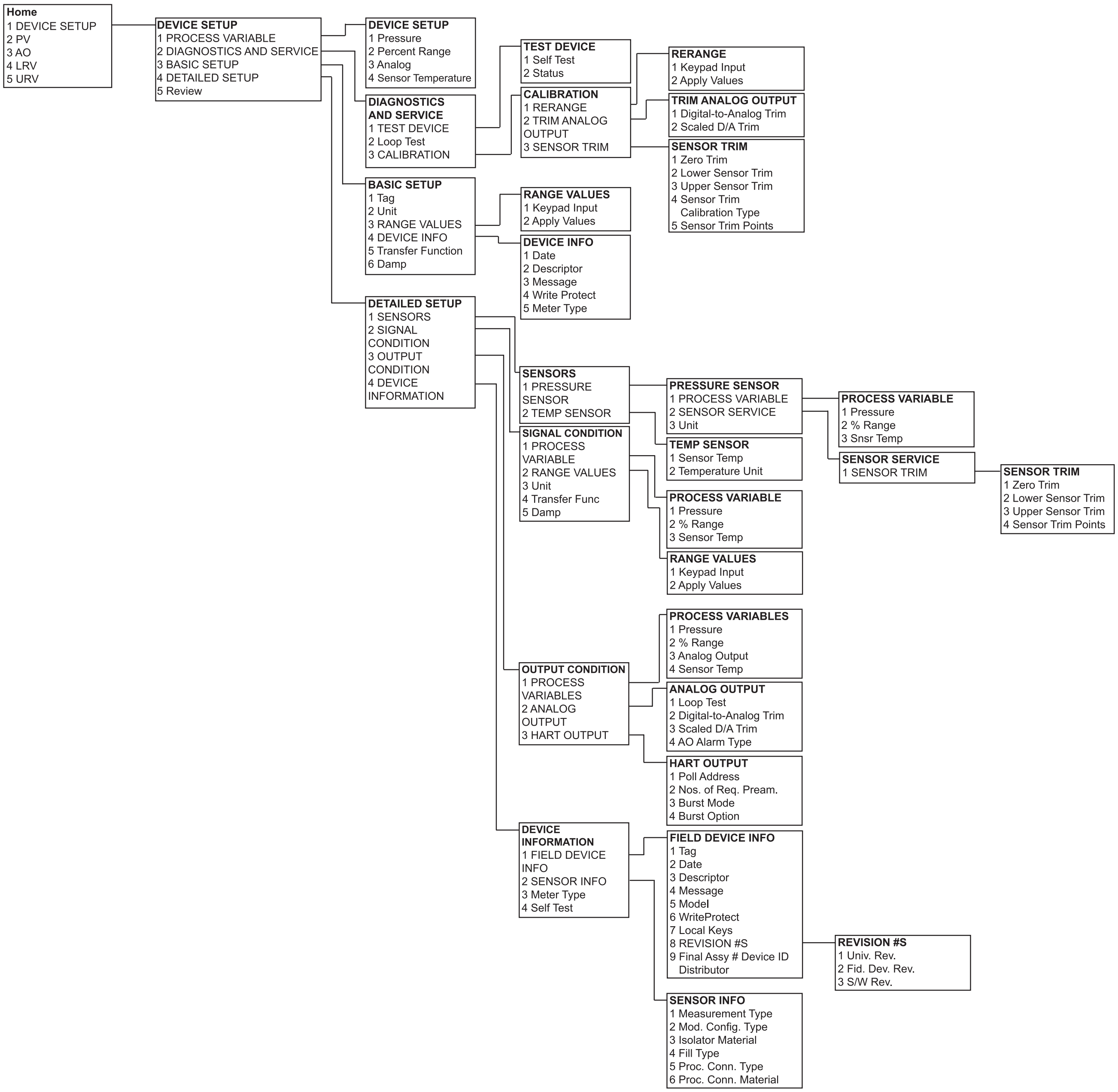


Figure 3-7. Rosemount 3051 device dashboard menu tree - overview

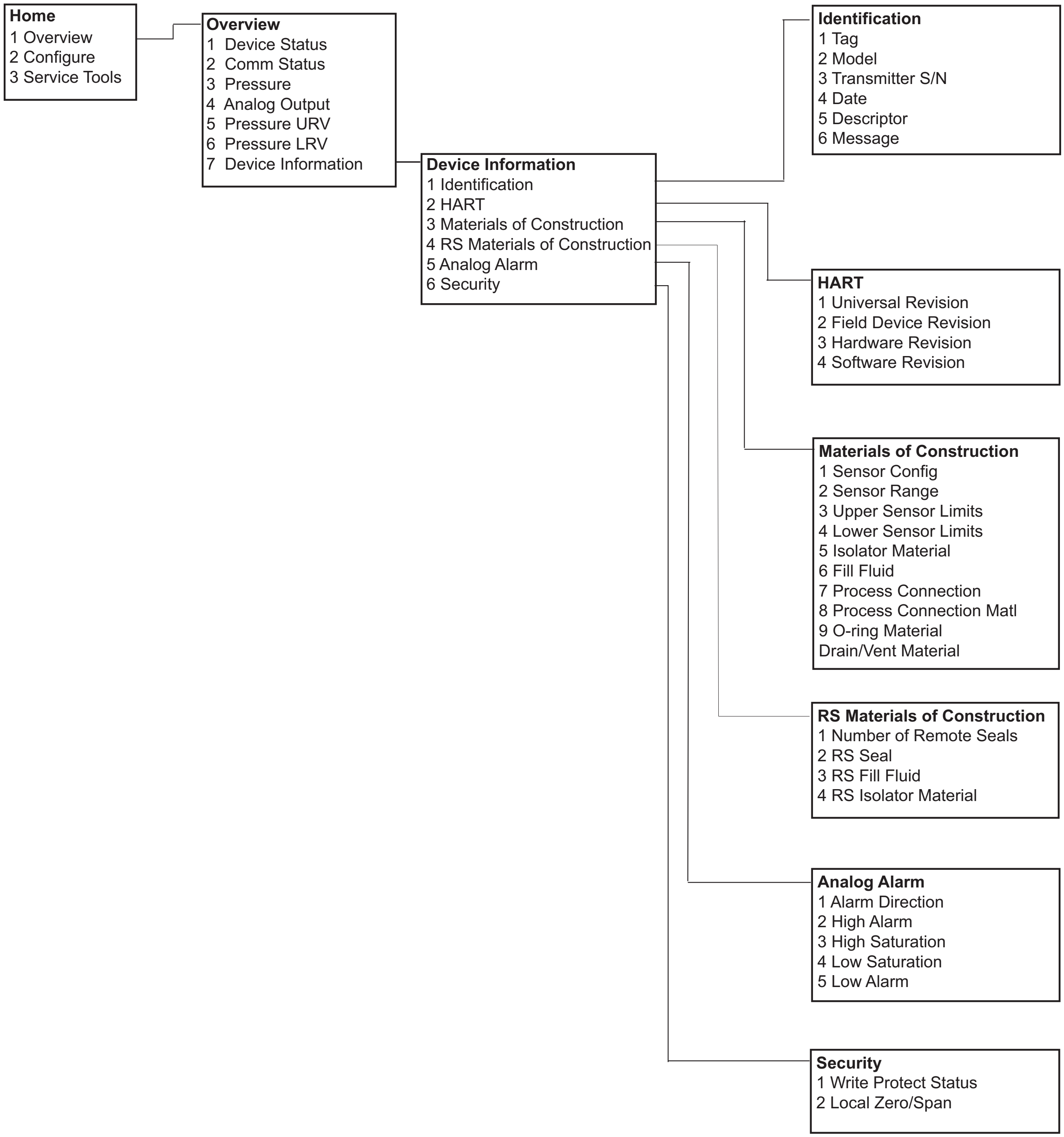


Figure 3-8. Rosemount 3051 device dashboard menu tree - configure

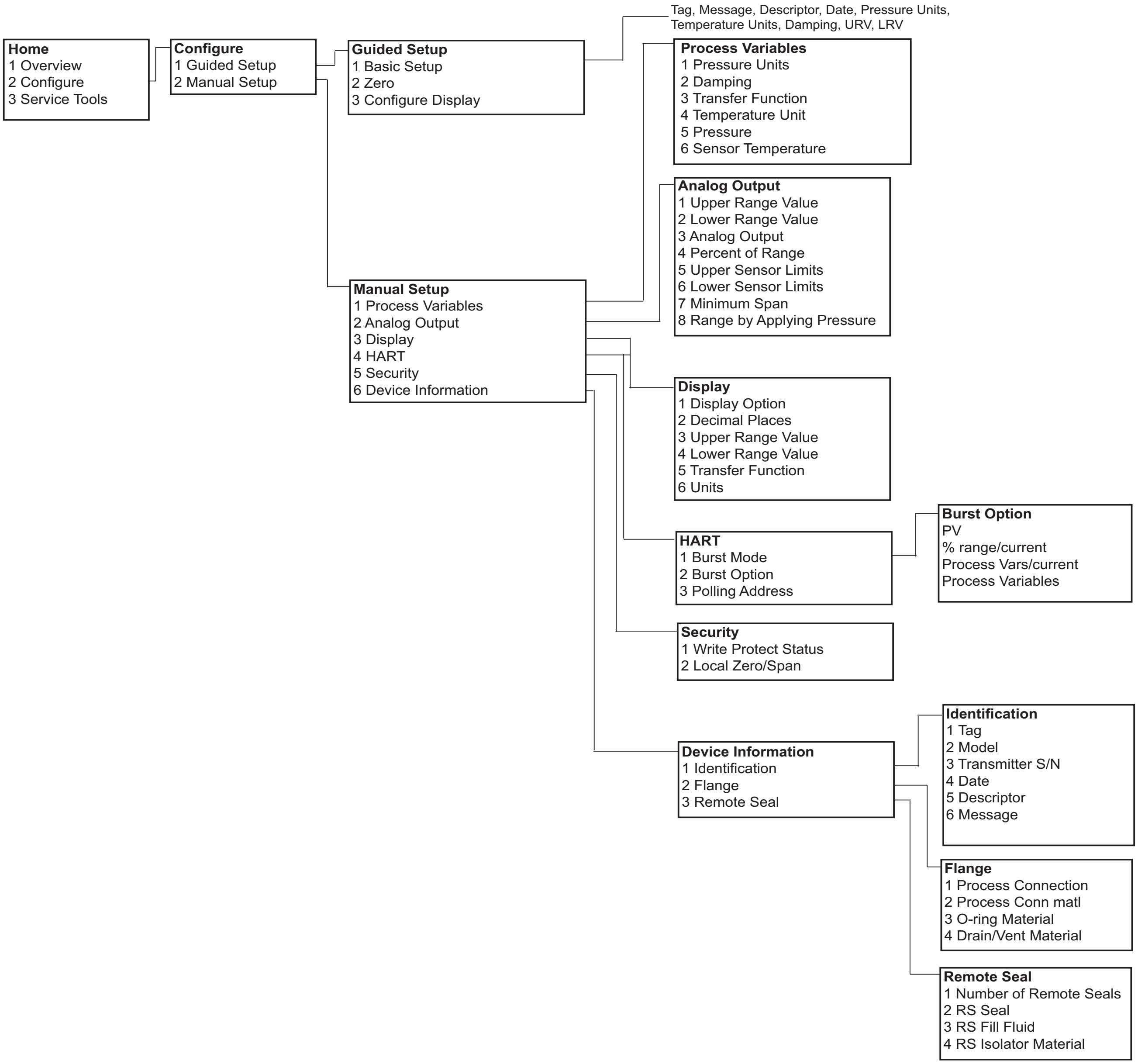
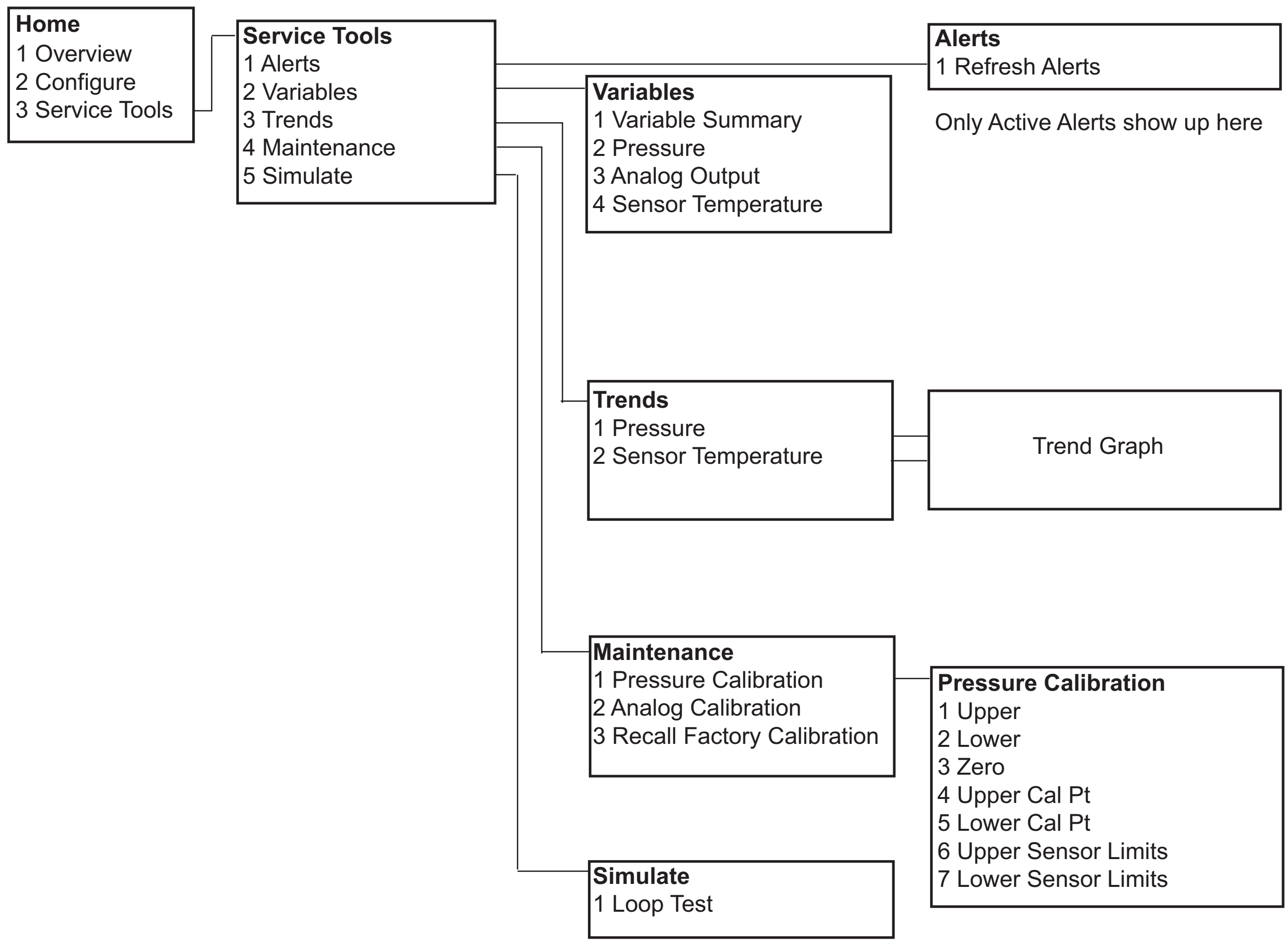


Figure 3-9. Rosemount 3051 device dashboard menu tree - service tools



3.7 Traditional fast key sequence

A check (√) indicates the basic configuration parameters. At minimum, these parameters should be verified as part of the configuration and startup procedure.

Table 3-1. 3051 Traditional fast key sequence

	Function	4-20 mA HART	1-5 Vdc HART low power
√	Alarm and Saturation Levels	1, 4, 2, 7	N/A
	Analog Output Alarm Type	1, 4, 3, 2, 4	1, 4, 3, 2, 4
	Burst Mode Control	1, 4, 3, 3, 3	1, 4, 3, 3, 3
	Burst Operation	1, 4, 3, 3, 4	1, 4, 3, 3, 4
	Custom Meter Configuration	1, 3, 7, 2	N/A

	Function	**4-20 mA HART**	**1-5 Vdc HART low power**
	Custom Meter Value	1, 4, 3, 4, 3	N/A
√	Damping	1, 3, 6	1, 3, 6
	Date	1, 3, 4, 1	1, 3, 4, 1
	Descriptor	1, 3, 4, 2	1, 3, 4, 2
	Digital To Analog Trim (4-20 mA Output)	1, 2, 3, 2, 1	1, 2, 3, 2, 1
	Disable Local Span/Zero Adjustment	1, 4, 4, 1, 7	1, 4, 4, 1, 7
	Field Device Information	1, 4, 4, 1	1, 4, 4, 1
	Full Trim	1, 2, 3, 3	1, 2, 3, 3
	Keypad Input – Rerange	1, 2, 3, 1, 1	1, 2, 3, 1, 1
	Local Zero and Span Control	1, 4, 4, 1, 7	1, 4, 4, 1, 7
	Loop Test	1, 2, 2	1, 2, 2
	Lower Sensor Trim	1, 2, 3, 3, 2	1, 2, 3, 3, 2
	Message	1, 3, 4, 3	1, 3, 4, 3
	Meter Options	1, 4, 3, 4	N/A
	Number of Requested Preambles	1, 4, 3, 3, 2	1, 4, 3, 3, 2
	Poll Address	1, 4, 3, 3, 1	1, 4, 3, 3, 1
	Poll a Multidropped Transmitter	Left Arrow, 4, 1, 1	Left Arrow, 4, 1, 1
√	Range Values	1, 3, 3	1, 3, 3
	Rerange	1, 2, 3, 1	1, 2, 3, 1
	Scaled D/A Trim (4–20 mA Output)	1, 2, 3, 2, 2	1, 2, 3, 2, 2
	Self Test (Transmitter)	1, 2, 1, 1	1, 2, 1, 1
	Sensor Info	1, 4, 4, 2	1, 4, 4, 2
	Sensor Temperature	1, 1, 4	1, 1, 4
	Sensor Trim Points	1, 2, 3, 3, 4	1, 2, 3, 3, 4
	Status	1, 2, 1, 2	1, 2, 1, 2
√	Tag	1, 3, 1	1, 3, 1
√	Transfer Function (Setting Output Type)	1, 3, 5	1, 3, 5
	Transmitter Security (Write Protect)	1, 3, 4, 4	1, 3, 4, 4
	Trim Analog Output	1, 2, 3, 2	1, 2, 3, 2
√	Units (Process Variable)	1, 3, 2	1, 3, 2
	Upper Sensor Trim	1, 2, 3, 3, 3	1, 2, 3, 3, 3
	Zero Trim	1, 2, 3, 3, 1	1, 2, 3, 3, 1

Table 3-2. 3051 device dashboard fast key sequence

Function	4-20 mA HART
Alarm and Saturation Levels	1, 7, 5
Analog Output Alarm Type	1, 7, 5
Burst Mode Control	2, 2, 4, 1
Burst Option	2, 2, 4, 2
Custom Display Configuration	2, 2, 3
Damping	2, 2, 1, 2
Date	2, 2, 6, 1, 4
Descriptor	2, 2, 6, 1, 5
Digital to Analog Trim (4 - 20 mA Output)	3, 4, 2
Disable Zero & Span Adjustment	2, 2, 5, 2
Field Device Information	2, 2, 6
Loop Test	3, 5, 1
Lower Sensor Trim	3, 4, 1, 2
Message	2, 2, 6, 1, 6
Poll Address	2, 2, 4, 3
Range Values	1, 5
Rerange with Keypad	1, 5
Scaled D/A Trim (4 - 20 mA Output)	3, 4, 2
Sensor Temperature/Trend	3, 3, 2
Tag	2, 2, 6, 1, 1
Transfer Function	2, 2, 1, 3
Transmitter Security (Write Protect)	2, 2, 5, 1
Units	2, 2, 1, 1
Upper Sensor Trim	3, 4, 1, 1
Zero Trim	3, 4, 1, 3

3.8 Check output

Before performing other transmitter on-line operations, review the digital output parameters to ensure that the transmitter is operating properly and is configured to the appropriate process variables.

3.8.1 Process variables

The process variables for the 3051 provide transmitter output, and are continuously updated. The pressure reading in both engineering units and percent of range will continue to track with pressures outside of the defined range from the lower to the upper range limit of the sensor module.

Field communicator

Traditional 4-20 mA Fast Keys	1, 1
Traditional 1-5 Vdc Fast Keys	1, 1
Device Dashboard Fast Keys	3, 2

The process variable menu displays the following process variables:

- Pressure
- Percent of range
- Analog output

AMS device manager

Right click on the device and select Process Variables... from the menu.The *Process Variable* screen displays the following process variables:

- Pressure
- Percent of range
- Analog output

3.8.2 Sensor temperature

The 3051 contains a temperature sensor near the pressure sensor in the sensor module. When reading this temperature, keep in mind the sensor is not a process temperature reading.

Field communicator

Traditional 4-20 mA Fast Keys	1, 1, 4
Traditional 1-5 Vdc Fast Keys	1, 1, 4
Device Dashboard Fast Keys	3, 2, 4

Enter the fast key sequence “Sensor Temperature” to view the sensor temperature reading.

AMS device manager

Right click on the device and select Process Variables... from the menu. “Snsr Temp” is the sensor temperature reading.

3.9 Basic setup

3.9.1 Set process variable units

The PV Unit command sets the process variable units to allow you to monitor your process using the appropriate units of measure.

Field communicator

Traditional 4-20 mA Fast Keys	1, 3, 2
Traditional 1-5 Vdc Fast Keys	1, 3, 2
Device Dashboard Fast Keys	2, 2, 1, 1

Enter the fast key sequence "Set Process Variable Units." Select from the following engineering units:

- inH_2O
- inHg
- ftH_2O
- mmH_2O
- mmHg
- psi
- bar
- mbar
- g/cm^2
- kg/cm^2
- Pa
- kPa
- torr
- atm
- inH_2O at 4 °C
- mmH_2O at 4 °C

AMS device manager

Right click on the device and select Configure from the menu. In the *Basic Setup* tab, select Unit from the drop down menu to select units.

3.9.2 Set output (Transfer function)

The 3051 has two output settings: Linear and Square Root. Activate the square root output option to make analog output proportional to flow. As input approaches zero, the 3051 automatically switches to linear output in order to ensure a more smooth, stable output near zero (see Figure 3-10).

For 4-20 mA HART output, the slope of the curve is unity (y = x) from 0 to 0.6 percent of the ranged pressure input. This allows accurate calibration near zero. Greater slopes would cause large changes in output (for small changes at input). From 0.6 percent to 0.8 percent, curve slope equals 42 (y = 42x) to achieve continuous transition from linear to square root at the transition point.

Field communicator

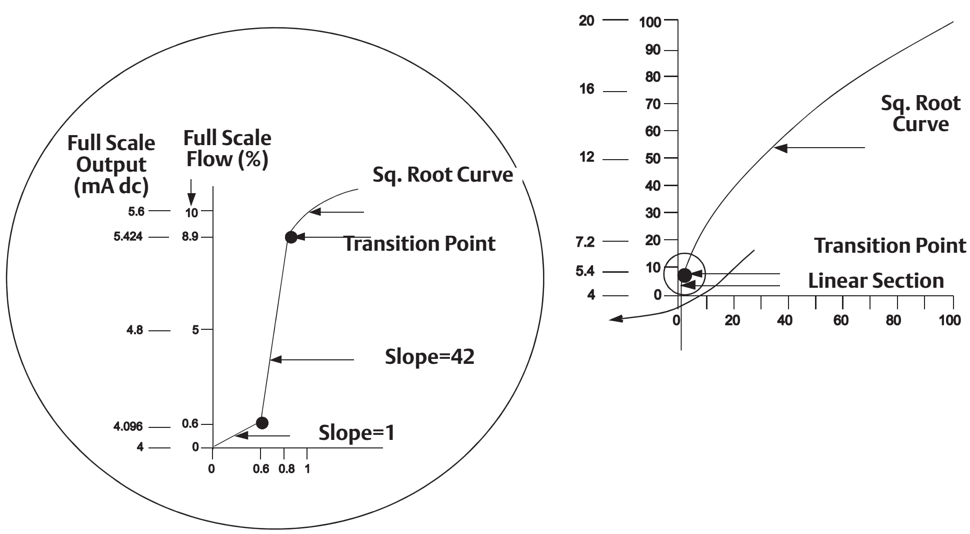
Traditional 4-20 mA Fast Keys	1, 3, 5
Traditional 1-5 Vdc Fast Keys	1, 3, 5
Device Dashboard Fast Keys	2, 2, 1, 3

AMS device manager

Right click on the device and select Configure from the menu.

1. In the *Basic Setup* tab, use Xfer fnctn drop down menu to select output, click Apply.
2. After carefully reading the warning provided, select yes.

Figure 3-10. 4-20 mA HART square root output transition point



Note
For a flow turndown of greater than 10:1 it is not recommended to perform a square root extraction in the transmitter. Instead, perform the square root extraction in the system.

3.9.3 Rerange

The Range Values command sets each of the lower and upper range analog values (4 and 20 mA points and 1 and 5 Vdc points) to a pressure. The lower range point represents 0% of range and the upper range point represents 100% of range. In practice, the transmitter range values may be changed as often as necessary to reflect changing process requirements. For a complete listing of Range & Sensor limits, refer to "Range and sensor limits" on page 108.

Note
Transmitters are shipped from Emerson Process Management fully calibrated per request or by the factory default of full scale (zero to upper range limit).

Note
Regardless of the range points, the 3051 will measure and report all readings within the digital limits of the sensor. For example, if the 4 and 20 mA points are set to 0 and 10 inH_2O, and the transmitter detects a pressure of 25 inH_2O, it digitally outputs the 25 inH_2O reading and a 250% of range reading.

Select from one of the methods below to rerange the transmitter. Each method is unique; examine all options closely before deciding which method works best for your process.

- Rerange with a Field Communicator or AMS Device Manager only.
- Rerange with a pressure input source and a Field Communicator or AMS Device Manager.
- Rerange with a pressure input source and the local zero and span buttons (option D4).

Note
If the transmitter security switch is **ON,** adjustments to the zero and span will not be able to be made. Refer to "Configure security and alarm" on page 20 for security information.

Rerange with a Field Communicator or AMS Device Manager Only.

The easiest and most popular way to rerange is to use the Field Communicator only. This method changes the range values of the analog 4 and 20 mA points (1 and 5 Vdc points) independently without a pressure input. This means that when you change either the 4 or 20 mA setting, you also change the span.

An example for the 4-20 mA HART output:

If the transmitter is ranged so that

4 mA = 0 inH_2O, and
20 mA = 100 inH_2O,

and you change the 4 mA setting to 50 inH_2O using the communicator only, the new settings are:

4 mA = 50 inH_2O, and
20 mA = 100 inH_2O.

Note that the span was also changed from 100 inH_2O to 50 inH_2O, while the 20 mA setpoint remained at 100 inH_2O.

To obtain reverse output, simply set the 4 mA point at a greater numerical value than the 20 mA point. Using the above example, setting the 4 mA point at 100 inH_2O and the 20 mA point at 0 inH_2O will result in reverse output.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 1
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 1
Device Dashboard Fast Keys	2, 2, 2, 1

From the *HOME* screen, enter the fast key sequence "Rerange with a Communicator Only."

AMS device manager

Right click on the device and select Configure from the menu. In the *Basic Setup* tab, locate the Analog Output box and perform the following procedure:

1. Enter the lower range value (LRV) and the upper range value (URV) in the fields provided. Click Apply.
2. After carefully reading the warning provided, select yes.

Rerange with a pressure input source and a field communicator or AMS device manager

Reranging using the Field Communicator and applied pressure is a way of reranging the transmitter when specific 4 and 20 mA points (1 and 5 Vdc points) are not calculated.

Note
The span is maintained when the 4 mA point (1 Vdc point) is set. The span changes when the 20 mA point (5 Vdc point) is set. If the lower range point is set to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 1, 2
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 1, 2
Device Dashboard Fast Keys	2, 2, 2, 8

From the *HOME* screen, enter the fast key sequence Rerange with a pressure input source and a field communicator or AMS device manager .

AMS device manager

Right click on the device, select Calibrate, then Apply values from the menu.

1. Select Next after the control loop is set to manual.
2. From the *Apply Values* menu, follow the on-line instructions to configure lower and upper range values.
3. Select Exit to leave the *Apply Values* screen.
4. Select Next to acknowledge the loop can be returned to automatic control.
5. Select Finish to acknowledge the method is complete.

Rerange with a pressure input source and the local zero and span buttons (option D4)

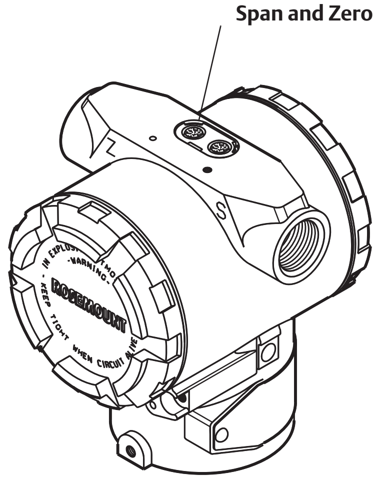
Reranging using the local zero and span adjustments (see Figure 3-11 on page 57) and a pressure source is a way of reranging the transmitter when specific 4 and 20 mA (1 and 5 Vdc) points are not known and a communicator is not available.

Note
When you set the 4 mA (1 Vdc) point the span is maintained; when you set the 20 mA (5 Vdc) point the span changes. If you set the lower range point to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

To rerange the transmitter using the span and zero buttons, perform the following procedure:

1. Loosen the screw holding the certifications label on the top of the transmitter housing. Slide the label to expose the zero and span buttons. See Figure 3-11.
2. Apply the desired 4 mA (1 Vdc) pressure value to the transmitter. Push and hold the zero adjustment button for at least two seconds but no longer than ten seconds.
3. Apply the desired 20 mA (5 Vdc) pressure value to the transmitter. Push and hold the span adjustment button for at least two seconds but no longer than ten seconds.

Figure 3-11. Zero and span buttons



Note
The span is maintained when the 4 mA point (1 Vdc point) is set. The span changes when the 20 mA point (5 Vdc point) is set. If the lower range point is set to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

3.9.4 Damping

The "Damp" command introduces a delay in the micro-processing which increases the response time of the transmitter; smoothing variations in output readings caused by rapid input changes. Determine the appropriate damping setting based on the necessary response time, signal stability, and other requirements of the loop dynamics within your system. The default damping value is 0.4 seconds and it can be set to any of ten pre-configured damping values between 0 and 25.6 seconds. See list below.

■ 0.00 seconds	■ 0.05 seconds	■ 0.10 seconds
■ 0.20 seconds	■ 0.40 seconds	■ 0.80 seconds
■ 1.60 seconds	■ 3.20 seconds	■ 6.40 seconds
■ 12.8 seconds	■ 25.6 seconds	

The current damping value can be determined by executing the Field Communicator fast keys or going to "Configure" in AMS Device Manager.

Field communicator

Traditional 4-20 mA Fast Keys	1, 3, 6
Traditional 1-5 Vdc Fast Keys	1, 3, 6
Device Dashboard Fast Keys	2, 2, 1, 2

AMS device manager

Right click on the device and select Configure from the menu.

1. In the *Basic Setup* tab, enter the damping value in the *Damp* field, click Apply.
2. After carefully reading the warning provided, select yes.

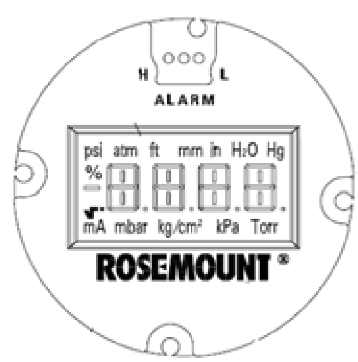
3.10 LCD display

The LCD display connects directly to the interface board which maintains direct access to the signal terminals. The display indicates output and abbreviated diagnostic messages. A display cover is provided to accommodate the display.

For 4-20 mA HART output, the LCD display features a two-line display. The first line of five characters displays the actual measured value, the second line of six characters displays the engineering units. The LCD can also display diagnostic messages. Refer to Figure 3-12.

For 1-5 Vdc HART Low Power output, the LCD display features a single-line display with four characters that display the actual value. The LCD can also display diagnostic messages. Refer to Figure 3-12.

Figure 3-12.

<table>
<tr><th>4-20 mA HART</th><th>1-5 Vdc HART Low Power</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

3.10.1 LCD display configuration for 4-20 mA HART only

The factory default alternates are between Engineering Units and % of Range. The LCD Display Configuration command allows customization of the LCD display to suit application requirements. The LCD display will alternate between the selected items:

■ Eng. Units only	■ Alternate Eng. Units & % of Range
■ % of Range only	■ Alternate Eng. Units & Custom Display
■ Custom Display only	■ Alternate % of Range & Custom Display

Field communicator

Traditional 4-20 mA Fast Keys	1, 3, 7
Device Dashboard Fast Keys	2, 2, 3

To change the standard default to one of the above options, follow these steps:

1. From the communicators main menu select (1) Device Setup, (3) Basic Setup, (7) Meter Options.
2. Select (1) Meter Type. Using the up or down arrows scroll up or down until the desired display has been highlighted. Press ENTER, SEND, and HOME.

AMS

Right click on the device and select Configuration Properties from the menu.

1. In the *Local Display* tab, locate the *Meter Type* area. Select the desired options to suit your application needs, click Apply.
2. An *Apply Parameter Modification* screen appears, enter desired information and click OK.
3. After carefully reading the warning provided, select OK.

3.10.2 Custom display configuration 4-20 mA HART only

The user-configurable scale is a feature that enables the LCD display to display flow, level, or custom pressure units. With this feature you can define the decimal point position, the upper range value, the lower range value, the engineering units, and the transfer function.The display can be configured using a Field Communicator or AMS.

The user-configurable scale feature can define:

- decimal point position
- upper range values
- lower range values
- engineering units
- transfer function

To configure the display with a Field Communicator, perform the following procedure:

1. Change the Meter Type to "Custom Meter" by using the Fast Key sequence under "LCD display configuration for 4-20 mA HART only" on page 59.

2. Next from the *ONLINE* screen, Select 1 Device Setup, 3 Basic Setup, 7 Meter Options, 2 Meter Options, 2 Custom Meter Setup.

3. To specify decimal point position:

   a. Select 1 Sel dec pt pos. Choose the decimal point representation that will provide the most accurate output for your application. For example, when outputting between 0 and 75 GPM, choose XX.XXX or use the decimal point examples below:

      XXXXX
      XXXX.X
      XXX.XX
      XX.XXX
      X.XXXX

Note
Make sure the selection has been sent and the decimal point has changed before proceeding to the next step.

   b. SEND

4. To specify a custom upper range value:

   a. Select *2 CM Upper Value*. Type the value that you want the transmitter to read at the 20 mA point.
   b. SEND

5. To specify a custom lower range value:

   a. Select *3 CM Lower Value*. Type the value that you want the transmitter to read at the 4 mA point.
   b. SEND

6. To define custom units:

   a. Select *4 CM Units*. Enter the custom units (five characters maximum) that you want the display to display.
   b. SEND

7. To choose the transmitter transfer function for the display:

   a. Select *5 CM xfer fnct*. Enter the transmitter transfer function for the display. Select *sq root* to display flow units. The custom meter transfer function is independent of the analog output transfer function.

8. Select SEND to upload the configuration to the transmitter.

⚠ See "Safety messages" on page 39 for complete warning information.

3.11 Detailed setup

3.11.1 Failure mode alarm and saturation

The 3051 transmitters automatically and continuously perform self-diagnostic routines. If the self-diagnostic routines detect a failure, the transmitter drives its output outside of the normal saturation values. The transmitter will drive its output low or high based on the position of the failure mode alarm jumper. See Table 3-3, Table 3-4, and Table 3-5 for failure mode and saturation output levels. To select alarm position, see "Configure security and alarm" on page 20.

Table 3-3. 4-20 mA HART alarm and saturation values

Level	4–20 mA saturation	4–20 mA alarm
Low	3.9 mA	≤ 3.75 mA
High	20.8 mA	≥ 21.75 mA

Table 3-4. NAMUR-Compliant alarm and saturation values

Level	4–20 mA saturation	4–20 mA alarm
Low	3.8 mA	≤ 3.6 mA
High	20.5 mA	≥ 22.5 mA

Table 3-5. 1-5 Vdc HART low-power alarm and saturation values

Level	1–5 V saturation	1–5 V alarm
Low	0.97 V	≤ 0.95 V
High	5.20 V	≥ 5.4 V

Caution
Alarm level values will be affected by analog trim. Refer to "Analog output trim" on page 77.

Note
When a transmitter is in an alarm condition, the Field Communicator indicates the analog output the transmitter would drive if the alarm condition did not exist. The transmitter will alarm high in the event of failure if the alarm jumper is removed.

3.11.2 Alarm and saturation levels for burst mode

Transmitters set to burst mode handle saturation and alarm conditions differently.

Alarm conditions:

- Analog output switches to alarm value
- Primary variable is burst with a status bit set
- Percent of range follows primary variable
- Temperature is burst with a status bit set

Saturation:

- Analog output switches to saturation value
- Primary variable is burst normally
- Temperature is burst normally

3.11.3 Alarm and saturation values for multidrop mode

Transmitters set to multidrop mode handle saturation and alarm conditions differently.

Alarm conditions:

- Primary variable is sent with a status bit set
- Percent of range follows primary variable
- Temperature is sent with a status bit set

Saturation:

- Primary variable is sent normally
- Temperature is sent normally

3.11.4 Alarm level verification

If the transmitter electronics board, sensor module, or LCD display is repaired or replaced, verify the transmitter alarm level before returning the transmitter to service. This feature is also useful in testing the reaction of the control system to a transmitter in an alarm state. To verify the transmitter alarm values, perform a loop test and set the transmitter output to the alarm value (see Tables 3-3, 3-4, and 3-5 on page 61, and "Loop test" on page 62).

3.12 Diagnostics and service

Diagnostics and service functions listed below are primarily for use after field installation. The Loop Test feature is designed to verify proper loop wiring and transmitter output.

3.12.1 Loop test

The Loop Test command verifies the output of the transmitter, the integrity of the loop, and the operations of any recorders or similar devices installed in the loop.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 2
Traditional 1-5 Vdc Fast Keys	1, 2, 2
Device Dashboard Fast Keys	3, 5, 1

To initiate a loop test, perform the following procedure:

1. a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
   b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.

2. From the *HOME* screen, enter the fast key sequence “Loop Test” to verify the output of the transmitter.

3. Select OK after the control loop is set to manual (see “Setting the loop to manual” on page 40).

4. Select a discrete milliamp level for the transmitter to output. At the CHOOSE ANALOG OUTPUT prompt select 1: 4mA (1 Vdc), select 2: 20mA (5 Vdc), or select 3: “Other” to manually input a value.
   a. If you are performing a loop test to verify the output of a transmitter, enter a value between 4 and 20 mA (1 and 5 Vdc).
   b. If you are performing a loop test to verify alarm levels, enter the value representing an alarm state (see Tables 3-3, 3-4, and 3-5 on page 61).

5. Check that the reference meter displays the commanded output value.
   a. If the values match, the transmitter and the loop are configured and functioning properly.
   b. If the values do not match, the meter may be attached to the wrong loop, there may be a fault in the wiring or power supply, the transmitter may require an output trim, or the reference meter may be malfunctioning.

After completing the test procedure, the display returns to the *Loop Test* screen to choose another output value or to end loop testing.

AMS device manager

Right click on the device and select Diagnostics and Test, then Loop Test from the menu.

1. a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
   b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.

2. Click Next after setting the control loop to manual.

3. Select desired analog output level. Click Next.

4. Click Next to acknowledge output being set to desired level.

5. Check that the reference meter displays the commanded output value.
   a. If the values match, the transmitter and the loop are configured and functioning properly.
   b. If the values do not match, the meter may be attached to the wrong loop, there may be a fault in the wiring or power supply, the transmitter may require an output trim, or the reference meter may be malfunctioning.

After completing the test procedure, the display returns to the *Loop Test* screen to choose another output value or to end loop testing.

6. Select End and click Next to end loop testing.

7. Select Next to acknowledge the loop can be returned to automatic control.

8. Select Finish to acknowledge the method is complete.

3.13 Advanced functions

3.13.1 Saving, recalling, and cloning configuration data

Use the cloning feature of the Field Communicator or the AMS Device Manager “User Configuration” feature to configure several 3051 transmitters similarly. Cloning involves configuring a transmitter, saving the configuration data, then sending a copy of the data to a separate transmitter. Several possible procedures exist when saving, recalling, and cloning configuration data. For complete instructions refer to the Field Communicator manual (publication no. 00809-0100-4276) or AMS Device Manager on-line guides. One common method is as follows:

Field communicator

Traditional 4-20 mA Fast Keys	left arrow, 1, 2
Traditional 1-5 Vdc Fast Keys	left arrow, 1, 2
Device Dashboard Fast Keys	3, 4, 3

1. Completely configure the first transmitter.
2. Save the configuration data:
   a. Select SAVE from the Field Communicator *HOME/ONLINE* screen.
   b. Ensure that the location to which the data will be saved is set to MODULE. If it is not, select 1: Location to set the save location to MODULE.
   c. Select 2: Name, to name the configuration data. The default is the transmitter tag number.
   d. Ensure that the data type is set to STANDARD. If the data type is NOT STANDARD, select 3: Data Type to set the data type to STANDARD.
   e. Select SAVE.
3. Connect and power the receiving transmitter and Field Communicator.
4. Select the back arrow from the *HOME/ONLINE* screen. The Field Communicator menu appears.
5. Select 1: Offline, 2: Saved Configuration, 1: Module Contents to reach the *MODULE CONTENTS* menu.
6. Use the DOWN ARROW to scroll through the list of configurations in the memory module, and use the RIGHT ARROW to select and retrieve the required configuration.
7. Select 1: Edit.
8. Select 1: Mark All.
9. Select SAVE.
10. Use the DOWN ARROW to scroll through the list of configurations in the memory module, and use the RIGHT ARROW to select the configuration again.
11. Select 3: Send to download the configuration to the transmitter.
12. Select OK after the control loop is set to manual.
13. After the configuration has been sent, select OK to acknowledge that the loop can be returned to automatic control.

When finished, the Field Communicator informs you of the status. Repeat Steps 3 through 13 to configure another transmitter.

Note
The transmitter receiving cloned data must have the same software version (or later) as the original transmitter.

AMS device manager creating a reusable copy

To create a reusable copy of a configuration perform the following procedure:

1. Completely configure the first transmitter.
2. Select View then User Configuration View from the menu bar (or click the toolbar button).
3. In the User Configuration window, right click and select New from the context menu.
4. In the *New* window, select a device from the list of templates shown, and click OK.
5. The template is copied into the User Configurations window, with the tag name highlighted; rename it as appropriate and press Enter.

Note
A device icon can also be copied by dragging and dropping a device template or any other device icon from AMS Device Manager Explorer or Device Connection View into the User Configurations window.

The “Compare Configurations” window appears, showing the Current values of the copied device on one side and mostly blank fields on the other (User Configuration) side.

6. Transfer values from the current configuration to the user configuration as appropriate or enter values by typing the values into the available fields.
7. Click Apply to apply the values, or click OK to apply the values and close the window.

AMS device manager applying a user configuration

Any amount of user configurations can be created for the application. They can also be saved, and applied to connected devices or to devices in the Device List or Plant Database.

Note
When using AMS Device Manager Revision 6.0 or later, the device to which the user configuration is applied, must be the same model type as the one created in the user configuration. When using AMS Device Manager Revision 5.0 or earlier, the same model type and revision number are required.

To apply a user configuration perform the following procedure:

1. Select the desired user configuration in the User Configurations window.
2. Drag the icon onto a like device in AMS Device Manager Explorer or Device Connection View. The Compare Configurations window opens, showing the parameters of the target device on one side and the parameters of the user configuration on the other.
3. Transfer parameters from the user configuration to the target device as desired. Click OK to apply the configuration and close the window.

3.13.2 Burst mode

When configured for burst mode, the 3051 provides faster digital communication from the transmitter to the control system by eliminating the time required for the control system to request information from the transmitter. Burst mode is compatible with the analog signal. Because the HART protocol features simultaneous digital and analog data transmission, the analog value can drive other equipment in the loop while the control system is receiving the digital information. Burst mode applies only to the transmission of dynamic data (pressure and temperature in engineering units, pressure in percent of range, and/or analog output), and does not affect the way other transmitter data is accessed.

Access to information other than dynamic transmitter data is obtained through the normal poll/response method of HART communication. A Field Communicator, AMS Device Manager or the control system may request any of the information that is normally available while the transmitter is in burst mode. Between each message sent by the transmitter, a short pause allows the Field Communicator, AMS Device Manager or a control system to initiate a request. The transmitter will receive the request, process the response message, and then continue “bursting” the data approximately three times per second.

Field communicator

Traditional 4-20 mA Fast Keys	1, 4, 3, 3, 3
Traditional 1-5 Vdc Fast Keys	1, 4, 3, 3, 3
Device Dashboard Fast Keys	2, 2, 4, 1

AMS device manager

Right click on the device and select Configure from the menu.

1. In the *HART* tab, use the drop down menu to select “Burst Mode ON or OFF.” For “Burst option” select the desired properties from the drop down menu. Burst options are as follows:
   - PV
   - % range/current
   - Process vars/crnt
   - Process variables
2. After selecting options click Apply.
3. After carefully reading the warning provided, select yes.

3.14 Multidrop communication

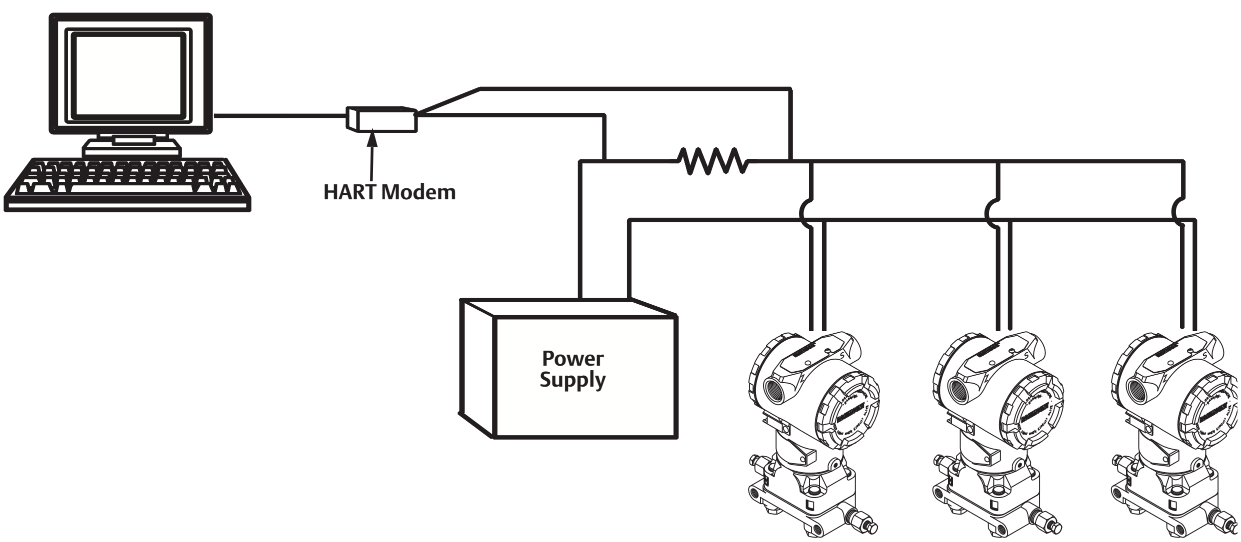
Multidropping transmitters refers to the connection of several transmitters to a single communications transmission line. Communication between the host and the transmitters takes place digitally with the analog output of the transmitters deactivated. With smart communications protocol, up to fifteen transmitters can be connected on a single twisted pair of wires, or over leased phone lines.

Multidrop installation requires consideration of the update rate necessary from each transmitter, the combination of transmitter models, and the length of the transmission line. Communication with transmitters can be accomplished with HART modems and a host implementing HART protocol. Each transmitter is identified by a unique address (1–15) and responds to the commands defined in the HART protocol. Field Communicators and AMS Device Manager can test, configure, and format a multidropped transmitter the same way as a transmitter in a standard point-to-point installation.

Figure 3-13 shows a typical multidrop network. This figure is not intended as an installation diagram.

Note
A transmitter in multidrop mode has the analog output fixed at 4 mA. If an LCD display is installed to a transmitter in multidrop mode, it will alternate the display between "current fixed" and the specified LCD display output(s).

Figure 3-13. Typical multidrop network



The 3051 is set to address zero (0) at the factory, which allows operation in the standard point-to-point manner with a 4–20 mA output signal. To activate multidrop communication, the transmitter address must be changed to a number from 1 to 15. This change deactivates the 4–20 mA analog output, sending it to 4 mA. It also disables the failure mode alarm signal, which is controlled by the upscale/downscale switch position. Failure signals in multidropped transmitters are communicated through HART messages.

3.15 Changing a transmitter address

To activate multidrop communication, the transmitter poll address must be assigned a number from 1 to 15, and each transmitter in a multidropped loop must have a unique poll address.

Field communicator

Traditional 4-20 mA Fast Keys	1, 4, 3, 3, 1
Traditional 1-5 Vdc Fast Keys	1, 4, 3, 3, 1
Device Dashboard Fast Keys	1, 2

AMS device manager

Right click on the device and select Configuration Properties from the menu.

1. In the *HART* tab, in *the ID* box, enter poll address located in the *Poll addr* box, click Apply.
2. After carefully reading the warning provided, select yes.

3.15.1 Communicating with a multidropped transmitter

Field communicator

Traditional 4-20 mA Fast Keys	1, 4, 3, 3, 2
Traditional 1-5 Vdc Fast Keys	1, 4, 3, 3, 2
Device Dashboard Fast Keys	1, 2

To communicate with a multidropped transmitter, configure the Field Communicator to poll for a non-zero address.

1. From the *HOME* screen, enter the fast key sequence “Communicating with a Multidropped Transmitter.”
2. On the polling menu, scroll down and select “Digital Poll.” In this mode, the Field Communicator automatically polls for devices at addresses 0-15 upon start up.

AMS device manager

Click on the HART modem icon and select Scan All Devices.

3.15.2 Polling a multidropped transmitter

Polling a multidropped loop determines the model, address, and number of transmitters on the given loop.

Field communicator

Traditional 4-20 mA Fast Keys	Left arrow, 4, 1
Traditional 1-5 Vdc Fast Keys	Left arrow, 4, 1
Device Dashboard Fast Keys	1, 2

AMS device manager

Click on the HART modem icon and select Scan All Devices.

Section 4 Operation and maintenance

4.1 Overview

This section contains information on calibrating and diagnostics messages on Rosemount 3051 Pressure Transmitters.

Field Communicator and AMS instructions are given to perform configuration functions. For convenience, Field Communicator fast key sequences are labeled “Fast Keys” for each software function below the appropriate headings.

4.2 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

4.2.1 Warnings

⚠ WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 3051 reference manual for any restrictions associated with a safe installation.

- Before connecting a Field Communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

4.3 Calibration overview

Calibration is defined as the process required to optimize transmitter accuracy over a specific range by adjusting the factory sensor characterization curve located in the microprocessor. Possible procedures are:

- Reranging: Setting the lower and upper range points (4 and 20 mA or 1 and 5 Vdc) points at required pressures. Reranging does not change the factory sensor characterization curve. Refer to page 53.
- Analog Output Trim: Adjusts the transmitter's analog characterization curve to match the plant standard of the control loop. There are two types of digital-to-analog output trims. Refer to page 77.
  - Digital-to-Analog Output Trim on 4-20 mA HART output (page 77)
  - Digital-to-Analog Output Trim on 4-20 mA HART output Using Other Scale (page 79)
- Sensor Trim: Adjusts the position of the factory sensor characterization curve due to a change in the sensor characteristics over time or a change in test equipment. Trimming has two steps, zero and sensor trims. Refer to page 82 and page 83.
- Zero Trim (page 82)
- Sensor Trim (page 83)

Figure 4-1 on page 73 illustrates 3051 transmitter data flow. Data flow can be summarized in four major steps:

1. A change in pressure is measured by a change in the sensor output (Sensor Signal).
2. The sensor signal is converted to a digital format that is understood by the microprocessor (Analog-to-Digital Signal Conversion). Sensor trim functions affect this value. Select these options to alter the digital signal on the LCD or Field Communicator.
3. Corrections are performed in the microprocessor to obtain a digital representation of the process input (Digital PV).
4. The Digital PV is converted to an analog value (Digital-to-Analog Signal Conversion). Rerange and Analog trim functions affect this value. Select these options to change the range points (4-20 mA or 1-5 Vdc).

For a summary of recommended calibration procedures, refer to Table 4-1 on page 4-74. Also, Figure 4-1 on page 73 identifies the approximate transmitter location for each calibration task. Data flows from left to right and a parameter change affects all values to the right of the changed parameter.

Figure 4-1. Transmitter data flow with calibration options

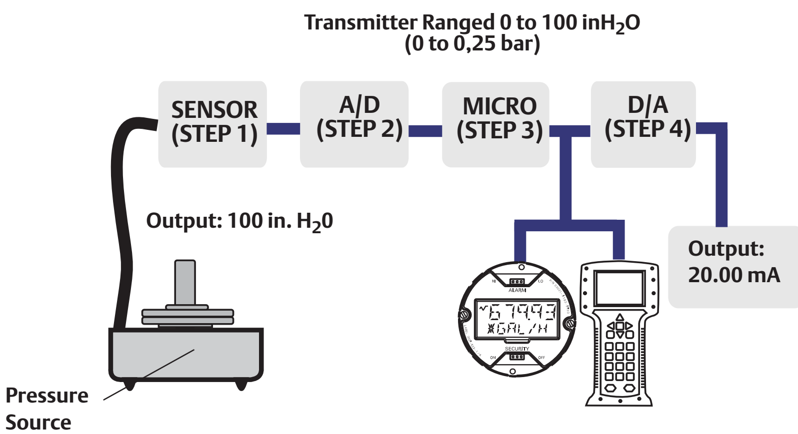


Table 4-1. Recommended calibration tasks

Transmitter	Bench calibration tasks	Field calibration tasks
3051CD 3051CG 3051L 3051TG, Range 1-4	1. Set output configuration parameters: a. Set the range points. b. Set the output units. c. Set the output type. d. Set the damping value. 2. *Optional*: Perform a sensor trim. (Accurate pressure source required.)	1. Reconfigure parameters if necessary. 2. Zero trim the transmitter to compensate for mounting effects or static pressure effects. 3. *Optional*: Perform an analog output trim. (Accurate multimeter required)
3051CA 3051TA 3051TG, Range 5	1. Set output configuration parameters: a. Set the range points. b. Set the output units. c. Set the output type. d. Set the damping value. 2. *Optional*: Perform a sensor trim if equipment available (accurate absolute pressure source required), otherwise perform the low trim value section of the sensor trim procedure.	1. Reconfigure parameters if necessary. 2. Perform low trim value section of the sensor trim procedure to correct for mounting position effects. 3. *Optional*: Perform an analog output trim (Accurate multimeter required)

Note
The 3051 has been carefully calibrated at the factory. Trimming adjusts the position of the factory characterization curve. It is possible to degrade performance of the transmitter if any trim is done improperly or with inaccurate equipment.

Note
A Field Communicator is required for all sensor and output trim procedures. Rosemount 3051C Range 4 and Range 5 transmitters require a special calibration procedure when used in differential pressure applications under high static line pressure (see "Select Finish to acknowledge the method is complete." on page 84).

4.3.1 Determining calibration frequency

Calibration frequency can vary greatly depending on the application, performance requirements, and process conditions. Use the following procedure to determine calibration frequency that meets the needs of your application.

1. Determine the performance required for your application.
2. Determine the operating conditions.
3. Calculate the Total Probable Error (TPE).
4. Calculate the stability per month.
5. Calculate the calibration frequency.

Sample calculation for a standard 3051C

Step 1: Determine the performance required for your application.

Required Performance:	0.30% of span

Step 2: Determine the operating conditions.

Transmitter:	3051CD, Range 2 [URL=250 inH_2O(623 mbar)]
Calibrated Span:	150 inH_2O (374 mbar)
Ambient Temperature Change:	± 50 °F (28 °C)
Line Pressure:	500 psig (34,5 bar)

Step 3: Calculate total probable error (TPE).

$$\text{TPE} = \sqrt{(\text{ReferenceAccuracy})^2 + (\text{TemperatureEffect})^2 + (\text{StaticPressureEffect})^2} = 0.117\% \text{ of span}$$

Where:

Reference Accuracy = ± 0.065% of span

$$\text{Ambient Temperature Effect} = \pm\left(\frac{(0.125 \quad \text{URL})}{\text{Span}} + 0.0625\right)\% \text{ per } 50\text{ °F} = \pm 0.0833\% \text{ of span}$$

Span Static Pressure Effect(1) =

$$0.1\% \text{ reading per 1000 psi (69 bar)} = \pm 0.05\% \text{ of span at maximum span}$$

(1)Zero static pressure effect removed by zero trimming at line pressure.

Step 4: Calculate the stability per month.

$$\text{Stability} = \pm\left[\frac{(0.125 \quad \text{URL})}{\text{Span}}\right]\% \text{ of span for 5 years} = \pm 0.0035\% \text{ of span per month}$$

Step 5: Calculate calibration frequency.

$$\text{Cal. Freq.} = \frac{(\text{Req. Performance} - \text{TPE})}{\text{Stability per Month}} = \frac{(0.30\% - 0.117\%)}{0.0035\%} = (52)\text{months}$$

Sample calculation for 3051C with P8 option (0.04% accuracy & 5-year stability)

Step 1: Determine the performance required for your application.

Required Performance:	0.30% of span

Step 2: Determine the operating conditions.

Transmitter:	3051CD, Range 2 [URL=250 inH_2O(623 mbar)]
Calibrated Span:	150 inH_2O (374 mbar)
Ambient Temperature Change:	± 50 °F (28 °C)
Line Pressure:	500 psig (34,5 bar)

Step 3: Calculate total probable error (TPE).

$$\text{TPE} = \sqrt{(\text{ReferenceAccuracy})^2 + (\text{TemperatureEffect})^2 + (\text{StaticPressureEffect})^2} = 0.105\% \text{ of span}$$

Where:

Reference Accuracy = ± 0.04% of span

Ambient Temperature Effect =

$$\pm\left(\frac{0.0125 \text{ ¥ URL}}{\text{Span}} + 0.0625\right)\% \text{ per } 50\ °\text{F} = \pm 0.0833\% \text{ of span}$$

Span Static Pressure Effect[1] =

0.1% reading per 1000 psi (69 bar) = ±0.05% of span at maximum span

(1)Zero static pressure effect removed by zero trimming at line pressure.

Step 4: Calculate the stability per month.

$$\text{Stability} = \pm\left[\frac{(0.125 \text{ ¥ URL})}{\text{Span}}\right]\% \text{ of span for 5 years} = \pm 0.0035\% \text{ of span per month}$$

Step 5: Calculate calibration frequency.

$$\text{Cal. Freq.} = \frac{(\text{Req. Performance} - \text{TPE})}{\text{Stability per Month}} = \frac{(0.3\% - 0.105\%)}{0.0035\%} = 27 \text{ months}$$

4.3.2 Choosing a trim procedure

To decide which trim procedure to use, you must first determine whether the analog-to-digital section or the digital-to-analog section of the transmitter electronics need calibration. Refer to Figure 4-1 and perform the following procedure:

1. Connect a pressure source, a Field Communicator or AMS, and a digital readout device to the transmitter.
2. Establish communication between the transmitter and the Field Communicator.
3. Apply pressure equal to the upper range point pressure.
4. Compare the applied pressure to the pressure process variable valve on the Process Variables menu on the Field Communicator or the *Process Variables* screen in AMS. For instructions on how to access process variables, see page 51 of Section 3: Configuration.

a. If the pressure reading does not match the applied pressure (with high-accuracy test equipment), perform a sensor trim. See "Sensor trim overview" on page 81 to determine which trim to perform.

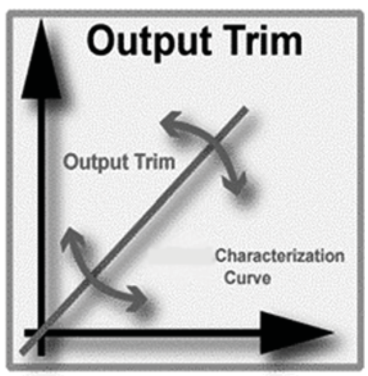
5. Compare the Analog Output (AO) line, on the Field Communicator or AMS, to the digital readout device.

If the AO reading does not match the digital readout device (with high-accuracy test equipment), perform an analog output trim. See "Analog output trim" on page 77.

4.4 Analog output trim

The Analog Output Trim commands allow you to adjust the transmitter's current output at the 4 and 20 mA (1 and 5 Vdc) points to match the plant standards. This command adjusts the digital to analog signal conversion.

Figure 4-2. Output trim



4.4.1 Digital-to-Analog trim

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 2, 1
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 2, 1
Device Dashboard Fast Keys	3, 4, 2

To perform a digital-to-analog trim with a Field Communicator, perform the following procedure.

1. From the *HOME* screen, enter the fast key sequence “Digital-to-Analog Trim.” Select OK after setting the control loop to manual, see “Setting the loop to manual” on page 40.
2. a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
   b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.
3. Select OK after connecting the reference meter.
4. Select OK at the SETTING FLD DEV OUTPUT TO 4 MA (1 Vdc) prompt. The transmitter outputs 4.0 mA.
5. Record the actual value from the reference meter, and enter it at the ENTER METER VALUE prompt. The Field Communicator prompts you to verify whether or not the output value equals the value on the reference meter.
6. Select 1: Yes, if the reference meter value equals the transmitter output value, or 2: No if it does not.
   a. If 1 is selected: Yes, proceed to Step 7.
   b. If 2 is selected: No, repeat Step 5.
7. Select OK at the SETTING FLD DEV OUTPUT TO 20 MA (5 Vdc) prompt, and repeat Steps 5 and 6 until the reference meter value equals the transmitter output value.
8. Select OK after the control loop is returned to automatic control.

AMS Device Manager

Right click on the device and select Calibrate, then D/A Trim from the menu.

1. Click Next after setting the control loop to manual.
2. Click Next after connecting the reference meter.
3. Click Next at the *Setting fld dev output to 4 mA (1 Vdc)* screen.
4. Record the actual value from the reference meter, and enter it at the *Enter meter value* screen and click Next.
5. Select Yes, if the reference meter value equals the transmitter output value, or No if it does not. Click Next.
   a. If Yes is selected, proceed to Step 6.
   b. If No is selected, repeat Step 4.
6. Click Next at the *Setting fld dev output to 20 mA (5 Vdc)* screen.
7. Repeat Step 4 - Step 5 until the reference meter equals the transmitter output value.
8. Select Next to acknowledge the loop can be returned to automatic control.
9. Select Finish to acknowledge the method is complete.

4.4.2 Digital-to-Analog trim using other scale

The Scaled D/A Trim command matches the 4 and 20 mA (1 and 5 Vdc) points to a user selectable reference scale other than 4 and 20 mA (for example, 2 to 10 volts if measuring across a 500 ohm load, or 0 to 100 percent if measuring from a Distributed Control System (DCS)). To perform a scaled D/A trim, connect an accurate reference meter to the transmitter and trim the output signal to scale, as outlined in the Output Trim procedure.

Note
Use a precision resistor for optimum accuracy. If you add a resistor to the loop, ensure that the power supply is sufficient to power the transmitter to a 20 mA output with additional loop resistance. Refer to "Power supply for 4-20 mA HART" on page 25.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 2, 2
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 2, 2
Device Dashboard Fast Keys	3, 4, 2

AMS Device Manager

Right click on the device and select Calibrate, then Scaled D/A trim from the menu.

1. Click Next after setting the control loop to manual.
2. Select Change to change scale, click Next.
3. Enter Set scale-Lo output value, click Next.
4. Enter Set scale-Hi output value, click Next.
5. Click Next to proceed with Trim.
6. Click Next after connecting the reference meter.
7. Click Next at the *Setting fld dev output to 4 mA* screen.
8. Record the actual value from the reference meter, and enter it at the *Enter meter value* screen and click Next.
9. Select Yes, if the reference meter value equals the transmitter output value, or No if it does not. Click Next.
   a. If Yes is selected, proceed to Step 10.
   b. If No is selected, repeat Step 8.
10. Click Next at the *Setting fld dev output to 20 mA* screen.
11. Repeat Step 8 - Step 9 until the reference meter equals the transmitter output value.
12. Select Next to acknowledge the loop can be returned to automatic control.
13. Select Finish to acknowledge the method is complete.

4.4.3 Recall factory trim—analog output

The Recall Factory Trim—Analog Output command allows the restoration of the as-shipped factory settings of the analog output trim. This command can be useful for recovering from an inadvertent trim, incorrect Plant Standard or faulty meter. This command is only available with 4-20 mA output.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 4, 2
Device Dashboard Fast Keys	3, 4, 3

AMS Device Manager

Right click on the device and select Calibrate, then Recall Factory Trim from the menu.

1. Click Next after setting the control loop to manual.
2. Select Analog output trim under *Trim to recall* and click Next.
3. Click Next to acknowledge restoration of trim values is complete.
4. Select Next to acknowledge the loop can be returned to automatic control.
5. Select Finish to acknowledge the method is complete.

4.5 Sensor trim

4.5.1 Sensor trim overview

Trim the sensor using either sensor or zero trim functions. Trim functions vary in complexity and are application-dependent. Both trim functions alter the transmitter's interpretation of the input signal.

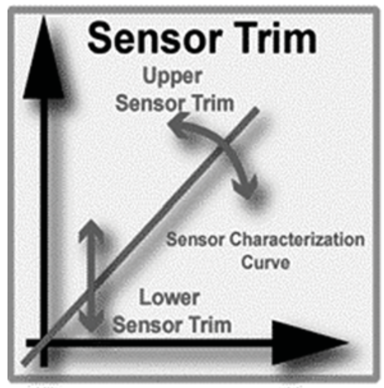
Zero trim is a single-point offset adjustment. It is useful for compensating for mounting position effects and is most effective when performed with the transmitter installed in its final mounting position. Since this correction maintains the slope of the characterization curve, it should not be used in place of a sensor trim over the full sensor range.

When performing a zero trim, ensure that the equalizing valve is open and all wet legs are filled to the correct levels.

Note
Do not perform a zero trim on Rosemount 3051T Absolute pressure transmitters. Zero trim is zero based, and absolute pressure transmitters reference absolute zero. To correct mounting position effects on a 3051T Absolute Pressure Transmitter, perform a low trim within the sensor trim function. The low trim function provides an offset correction similar to the zero trim function, but it does not require zero-based input.

Sensor trim is a two-point sensor calibration where two end-point pressures are applied, and all output is linearized between them. Always adjust the low trim value first to establish the correct offset. Adjustment of the high trim value provides a slope correction to the characterization curve based on the low trim value. The trim values allow you to optimize performance over your specified measuring range at the calibration temperature.

Figure 4-3. Sensor trim



4.5.2 Zero trim

Note
The transmitter PV at zero pressure must be within three percent of URL in order to calibrate using the zero trim function.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 3, 1
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 3, 1
Device Dashboard Fast Keys	3, 4, 1, 3

Calibrate the sensor with a Field Communicator using the zero trim function as follows:

1. Vent the transmitter and attach a Field Communicator to the measurement loop.
2. From the *HOME* screen, follow the fast key sequence “Zero Trim.”
3. Follow the commands provided by the Field Communicator to complete the zero trim adjustment.

AMS Device Manager

Right click on the device and select Calibrate, then Zero trim from the menu.

1. Click Next after setting the control loop to manual.
2. Click Next to acknowledge warning.
3. Click Next after applying appropriate pressure to sensor.
4. Select Next to acknowledge the loop can be returned to automatic control.
5. Select Finish to acknowledge the method is complete.

4.5.3 Sensor trim

Note
Use a pressure input source that is at least four times more accurate than the transmitter, and allow the input pressure to stabilize for ten seconds before entering any values.

Field communicator

Traditional 4-20 mA Fast Keys	1, 2, 3, 3
Traditional 1-5 Vdc Fast Keys	1, 2, 3, 3
Device Dashboard Fast Keys	3, 4, 1

To calibrate the sensor with a Field Communicator using the sensor trim function, perform the following procedure:

1. Assemble and power the entire calibration system including a transmitter, Field Communicator, power supply, pressure input source, and readout device.
2. From the *HOME* screen, enter the fast key sequence under “Sensor Trim.”
3. Select 2: Lower sensor trim. The lower sensor trim value should be the sensor trim point that is closest to zero.

Examples:

Calibration: 0 to 100" H_2O - lower trim = 0, upper trim = 100

Calibration: -100 to 0” H_2O - lower trim = 0, upper trim = -100

Calibration: -100 to 100” H_2O - lower trim = -100 or 100,
upper trim = -100 or 100

Note
Select pressure input values so that lower and upper values are equal to or outside the 4 and 20 mA (1 and 5 Vdc) points. Do not attempt to obtain reverse output by reversing the high and low points. This can be done by going to “Rerange” on page 53 of Section 3: Configuration. The transmitter allows approximately five percent deviation.

4. Follow the commands provided by the Field Communicator to complete the adjustment of the lower value.
5. Repeat the procedure for the upper value, replacing 2: Lower sensor trim with 3: Upper sensor trim in Step 3.

AMS Device Manager

Right click on the device and select Calibrate, then Sensor trim" from the menu.

1. Select Lower sensor trim. The lower sensor trim value should be the sensor trim point that is closest to zero.
2. Click Next after setting the control loop to manual.
3. Click Next after applying appropriate pressure to sensor.
4. Select Next to acknowledge the loop can be returned to automatic control.
5. Select Finish to acknowledge the method is complete.
6. Right click on the device and select Calibrate, select Sensor trim from the menu.
7. Select Upper sensor trim and repeat steps 5.

4.5.4 Recall factory trim—sensor trim

The Recall Factory Trim—Sensor Trim command allows the restoration of the as-shipped factory settings of the sensor trim. This command can be useful for recovering from an inadvertent zero trim of an absolute pressure unit or inaccurate pressure source. This command is only available with 4-20 mA output.

Field communicator

4-20 mA Fast Keys	1, 2, 3, 4, 1
Device Dashboard Fast Keys	3, 4, 3

AMS Device Manager

Right click on the device and select Calibrate, then Recall Factory Trim from the menu.

1. Click Next after setting the control loop to manual.
2. Select "Sensor trim" under *Trim to recall* and click Next.
3. Click Next to acknowledge restoration of trim values is complete.
4. Select Next to acknowledge the loop can be returned to automatic control.
5. Select Finish to acknowledge the method is complete.

4.5.5 Line pressure effect (range 2 and range 3)

The following specifications show the static pressure effect for the Rosemount 3051 Range 2 and Range 3 pressure transmitters used in differential pressure applications where line pressure exceeds 2000 psi (138 bar).

Zero effect

± 0.1% of the upper range limit plus an additional ± 0.1% of upper range limit error for each 1000 psi (69 bar) of line pressure above 2000 psi (138 bar).

Example: Line pressure is 3000 psi (207 bar) for Ultra performance transmitter. Zero effect error calculation:

± {0.05 + 0.1 x [3 kpsi - 2 kpsi]} = ± 0.15% of the upper range limit

Span effect

Refer to "Line Pressure Effect" on page 105.

4.5.6 Compensating for line pressure

Rosemount 3051 Range 4 and 5 pressure transmitters require a special calibration procedure when used in differential pressure applications. The purpose of this procedure is to optimize transmitter performance by reducing the effect of static line pressure in these applications. The 3051 differential pressure transmitters (Ranges 1, 2, and 3) do not require this procedure because optimization occurs in the sensor.

Applying high static pressure to 3051 Range 4 and Range 5 pressure transmitters causes a systematic shift in the output. This shift is linear with static pressure; correct it by performing the Sensor Trim procedure on page 83.

The following specifications show the static pressure effect for 3051 Range 4 and Range 5 transmitters used in differential pressure applications:

Zero Effect:

± 0.1% of the upper range limit per 1000 psi (69 bar) for line pressures from 0 to 2000 psi (0 to 138 bar)

For line pressures above 2000 psi (138 bar), the zero effect error is ± 0.2% of the upper range limit plus an additional ± 0.2% of upper range limit error for each 1000 psi (69 bar) of line pressure above 2000 psi (138 bar).

Example: Line pressure is 3000 psi (3 kpsi). Zero effect error calculation:

± {0.2 + 0.2 x [3 kpsi - 2 kpsi]} = ± 0.4% of the upper range limit

Span Effect:

Correctable to ±0.2% of reading per 1000 psi (69 bar) for line pressures from 0 to 3626 psi (0 to 250 bar)

The systematic span shift caused by the application of static line pressure is -1.00% of reading per 1000 psi (69 bar) for Range 4 transmitters, and -1.25% of reading per 1000 psi (69 bar) for Range 5 transmitters.

Use the following example to compute corrected input values.

Example

A Range 4 transmitter with model number 3051_CD4 will be used in a differential pressure application where the static line pressure is 1200 psi (83 bar). The transmitter output is ranged with 4 mA at 500 inH_2O (1,2 bar) and 20 mA at 1500 inH_2O (3,7 bar).

To correct for systematic error caused by high static line pressure, first use the following formulas to determine corrected values for the low trim and high trim.

Low Trim Value

LT = LRV - (S/100 x P/1000 x LRV)

Where:	LT =	Corrected Low Trim Value
	LRV =	Lower Range Value
	S =	Span shift per specification (as a percent of reading)
	P =	Static Line Pressure in psi

In this example:

LRV =	500 inH_2O (1.24 bar)
S =	-1.00%
P =	1200 psi
LT =	500 inH_2O - (-1%/100 x 1200 psi/1000 x 500 inH_2O)
LT =	506 inH_2O

High Trim Value

HT = (URV - (S/100 x P/1000 x URV)

Where:	HT =	Corrected High Trim Value
	URV =	Upper Range Value
	S =	Span shift per specification (as a percent of reading)
	P =	Static Line Pressure in psi

In this example:

URV =	1500 inH_2O (3.74 bar)
S =	-1.00%
P =	1200 psi
HT =	1500 - (-1%/100 x 1200 psi/1000 x 1500 inH_2O)
HT =	1518 inH_2O

Complete the Sensor Trim procedure as described on page 83. In the example above, at step 4, apply the nominal pressure value of 500 inH_2O. However, enter the calculated correct lower trim (LT) value of 506 inH_2O with the Field Communicator. Repeat the procedure for the upper value.

Note

The range values for the 4 and 20 mA (1 and 5 Vdc) points should be at the nominal URV and LRV. In the example above, the values are 1500 inH_2O and 500 inH_2O respectively. Confirm the values on the *HOME* screen on the Field Communicator. Modify, if needed, by following the steps in the Rerange section on page 53.

Section 5 Troubleshooting

5.1 Overview

Table 5-1 provides summarized maintenance and troubleshooting suggestions for the most common operating problems.

If you suspect malfunction despite the absence of any diagnostic messages on the Field Communicator display, consider using Table 5-1 on page 5-91 to identify any potential problem.

5.2 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

5.2.1 Warnings (⚠)

⚠ WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 3051 reference manual for any restrictions associated with a safe installation.

- Before connecting a Field Communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

Table 5-1. Rosemount 3051 troubleshooting table for 4-20 mA output

Symptom	Corrective actions
Transmitter milliamp reading is zero	Verify power is applied to signal terminals
	Check power wires for reversed polarity
	Verify terminal voltage is 10.5 to 42.4 Vdc
	Check for open diode across test terminal
Transmitter Not Communicating with Field Communicator	Verify the output is between 4 and 20 mA or saturation levels
	Verify terminal voltage is 10.5 to 42.4 Vdc
	Verify clean DC Power to transmitter (Max AC noise 0.2 volts peak to peak)
	Check loop resistance, 250 Ω minimum (PS voltage -transmitter voltage/loop current)
	Have Field Communicator poll for all addresses
Transmitter milliamp reading is low or high	Verify applied pressure
	Verify 4 and 20 mA range points
	Verify output is not in alarm condition
	Verify if 4 – 20 mA output trim is required
Transmitter will not respond to changes in applied pressure	Check test equipment
	Check impulse piping or manifold for blockage
	Verify the transmitter is not in multidrop mode
	Verify applied pressure is between the 4 and 20 mA set points
	Verify output is not in alarm condition
	Verify transmitter is not in Loop Test mode
Digital Pressure Variable reading is low or high	Check test equipment (verify accuracy)
	Check impulse piping for blockage or low fill in wet leg
	Verify transmitter is calibrated properly
	Verify pressure calculations for application
Digital Pressure Variable reading is erratic	Check application for faulty equipment in pressure line
	Verify transmitter is not reacting directly to equipment turning on/off
	Verify damping is set properly for application
Milliamp reading is erratic	Verify power source to transmitter has adequate voltage and current
	Check for external electrical interference
	Verify transmitter is properly grounded
	Verify shield for twisted pair is only grounded at one end

5.3 Diagnostic messages

In addition to the output, the LCD meter displays abbreviated operation, error, and warning messages for troubleshooting the transmitter. Messages appear according to their priority, with normal operating messages appearing last. To determine the cause of a message, use a Field Communicator or AMS to further interrogate the transmitter. A description of each LCD diagnostic message follows.

Error

Error messages appear on the LCD display to inform you of serious problems affecting the operation of the transmitter. The LCD displays an error message until the error condition is corrected, and the analog output is driven to the specified alarm level. No other transmitter information is displayed during an alarm condition.

Fail

The transmitter CPU board and the sensor module are incompatible. See “Disassembly procedures” on page 97.

Fail Module

The sensor module is disconnected or is malfunctioning. Verify that the sensor module ribbon cable is connected to the back of the electronics board. If the ribbon cable is properly connected, there is a problem within the sensor module. Possible sources of problems include:

- Pressure or temperature updates are not being received in the sensor module.
- A non-volatile memory fault that will effect transmitter operation has been detected in the module by the memory verification routine.

Some non-volatile memory faults are user-repairable. Use a Field Communicator to diagnose the error and determine if it is repairable. Any error message that ends in “FACTORY” is not repairable. In cases of non user-repairable errors, you must replace the transmitter.

Fail Elect

The transmitter electronics board is malfunctioning due to an internal fault. Some of the FAIL ELECT errors are user-repairable. Use a 275 Field Communicator to diagnose the error and determine if it is repairable. Any error message that ends in “FACTORY” is not repairable. In cases of non user-repairable errors, you must replace the electronics board. See “Disassembly procedures” on page 97.

Fail Config

A memory fault has been detected in a location that could affect transmitter operation, and is user-accessible. To correct this problem, use a Field Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory.

Warnings

Warnings appear on the LCD display to alert you of user-repairable problems with the transmitter, or current transmitter operations. Warnings appear alternately with other transmitter information until the warning condition is corrected or the transmitter completes the operation that warrants the warning message.

Press Limit

The process variable read by the transmitter is outside of the transmitter's range.

Temp Limit

The secondary temperature variable read by the transmitter is outside of the transmitter's range.

Curr Fixed

The transmitter is in multidrop mode. The analog output is not tracking pressure changes.

Curr Saturd

The pressure read by the module is outside of the specified range, and the analog output has been driven to saturation levels.

Loop Test

A loop test is in progress. During a loop test or 4–20 mA trim, the analog output is set to a fixed value. The meter display alternates between the current selected in milliamps and "LOOP TEST."

Xmtr Info

A non-volatile memory fault has been detected in the transmitter memory by the memory verification routine. The memory fault is in a location containing transmitter information. To correct this problem, use a Field Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory. This warning does not effect the transmitter operation.

Operation

Normal operation messages appear on the LCD meter to confirm actions or inform you of transmitter status. Operation messages are displayed with other transmitter information, and warrant no action to correct or alter the transmitter settings.

Zero Pass

The zero value, set with the local zero adjustment button, has been accepted by the transmitter, and the output should change to 4 mA
(1 Vdc).

Zero Fail

The zero value, set with the local zero adjustment button, exceeds the maximum rangedown allowed for a particular range, or the pressure sensed by the transmitter exceeds the sensor limits.

Span Pass

The span value, set with the local span adjustment button, has been accepted by the transmitter, and the output should change to 20 mA
(5 Vdc).

Span Fail

The span value, set with the local span adjustment button, exceeds the maximum rangedown allowed for a particular range, or the pressure sensed by the transmitter exceeds the sensor limits.

Local Dsbld

This message appears during reranging with the integral zero and span buttons and indicates that the transmitter local zero and span adjustments have been disabled. The adjustments may have been disabled by the transmitter security jumper on the transmitter circuit board or through software commands from the Field Communicator. See “Security (write protect)” on page 20 for information on the position of the security jumper and information on software lockout.

Write Protect

This message appears if you attempt to change the transmitter configuration data while the security jumper is in the ON position. See “Security (write protect)” on page 20 for more information about the security jumper.

Field communicator diagnostics

Table 5-2 is a list of messages used by the Field Communicator (HC) and their corresponding descriptions.

Variable parameters within the text of a message are indicated with <*variable parameter*>.

Reference to the name of another message is identified by
[another message].

Table 5-2. Field communicator messages

Message	Description
1k snsr EEPROM error-factory ON	Replace the transmitter
1k snsr EEPROM error-user-no out ON	Use the Field Communicator to reset the following parameters: remote seal isolator, remote seal fill fluid, flange material, o-ring material, transmitter type, remote seal type, flange type, meter type, number of remote seals.
1k snsr EEPROM error-user ON	Perform a full trim to recalibrate the transmitter.
4k micro EEPROM error-factory ON	Replace the electronics board.
4k micro EEPROM error-user-no out ON	Use the Field Communicator to reset the message field.
4k micro EEPROM error-user ON	Use the Field Communicator to reset the following parameters: units, range values, damping, analog output, transfer function, tag, scaled meter values. Perform a D/A trim to ensure that the error is corrected.

Message	Description
4k snsr EEPROM error-factory ON	Replace the transmitter.
4k snsr EEPROM error-user ON	Use the Field Communicator to reset the temperature units and the calibration type.
Add item for ALL device types or only for this ONE device type.	Asks the user whether the hot key item being added should be added for all device types or only for the type of device that is connected.
Command Not Implemented	The connected device does not support this function.
Communication Error	The communicator and the device are not communicating correctly. Check all connections between the Field Communicator and the device and resend the information.
Configuration memory not compatible with connected device	The configuration stored in memory is incompatible with the device to which a transfer has been requested.
CPU board not initialized ON	The electronics board is not initialized. Replace the electronics board.
CPU EEPROM write failure ON	Message sent to electronics board from HART signal failed. Replace the electronics board.
Device Busy	The connected device is busy performing another task.
Device Disconnected	The device failed to respond to a command. Check all connections between the Field Communicator and the device and resend the command.
Device write protected	Device is in write-protect mode. Data can not be written.
Device write protected. Do you still want to shut off?	Device is in write-protect mode. Press YES to turn the Field Communicator off and lose the unsent data.
Display value of variable on hotkey menu?	Asks whether the value of the variable should be displayed adjacent to its label on the hotkey menu if the item being added to the hotkey menu is a variable.
Download data from configuration memory to device	Press the SEND softkey to transfer information from the communicator memory to the device.
Exceed field width	Indicates that the field width for the current arithmetic variable exceeds the device-specified description edit format.
Exceed precision	Indicates that the precision for the current arithmetic variable exceeds the device-specified description edit format.
Ignore next 50 occurrences of status?	Select YES to ignore the next 50 occurrences of device status, or select no to display every occurrence.
Illegal character	An invalid character for the variable type was entered.
Illegal date	The day portion of the date is invalid.
Illegal month	The month portion of the date is invalid.
Illegal year	The year portion of the date is invalid.
Incompatible CPU board and module ON	Upgrade the electronics board or the sensor module to the current revision.
Incomplete exponent	The exponent of a scientific notation floating point variable is incomplete.
Incomplete field	The value entered is not complete for the variable type.

Message	Description
Looking for a device	Polling for multidropped devices at addresses 1–15.
Local buttons operator error ON	Illegal pressure applied during zero or span operation. Repeat the process after verifying the correct pressures.
Mark as read only variable on hotkey menu?	Asks whether the user should be allowed to edit the variable from the hotkey menu if the item being added to the hotkey menu is a variable.
Module EEPROM write failure ON	Message sent to the module from the HART signal failed. Replace the transmitter.
No device configuration in configuration memory	There is no configuration saved in memory available to re-configure off-line or transfer to a device.
No Device Found	Poll of address zero fails to find a device, or poll of all addresses fails to find a device if auto-poll is enabled.
No hotkey menu available for this device.	There is no menu named “hotkey” defined in the device description for this device.
No pressure updates ON	No pressure updates being received from the sensor module. Verify that the sensor module ribbon cable is attached correctly. Or replace the transmitter.
No offline devices available.	There are no device descriptions available to be used to configure a device offline.
No simulation devices available.	There are no device descriptions available to simulate a device.
No temperature updates ON	No temperature updates being received from the sensor module. Verify that the sensor module ribbon cable is attached correctly. Or replace the transmitter.
No UPLOAD_VARIABLES in ddl for this device	There is no menu named “upload_variables” defined in the device description for this device. This menu is required for offline configuration.
No Valid Items	The selected menu or edit display contains no valid items.
OFF KEY DISABLED	Appears when the user attempts to turn the HC off before sending modified data or before completing a method.
Online device disconnected with unsent data. RETRY or OK to lose data.	There is unsent data for a previously connected device. Press RETRY to send data, or press OK to disconnect and lose unsent data.
Out of memory for hotkey configuration. Delete unnecessary items.	There is no more memory available to store additional hotkey items. Unnecessary items should be deleted to make space available.
Overwrite existing configuration memory	Requests permission to overwrite existing configuration either by a device-to-memory transfer or by an offline configuration. User answers using the softkeys.
Press OK...	Press the OK softkey. This message usually appears after an error message from the application or as a result of HART communications.
Restore device value?	The edited value that was sent to a device was not properly implemented. Restoring the device value returns the variable to its original value.
ROM checksum error ON	Checksum of transmitter software has detected a fault. Replace the electronics board.
Save data from device to configuration memory	Prompts user to press SAVE softkey to initiate a device-to-memory transfer.

Message	Description
Saving data to configuration memory.	Data is being transferred from a device to configuration memory.
Sending data to device.	Data is being transferred from configuration memory to a device.
Sensor board not initialized ON	The sensor module electronics board is not initialized. Replace the transmitter.
There are write only variables which have not been edited. Please edit them.	There are write-only variables which have not been set by the user. These variables should be set or invalid values may be sent to the device.
There is unsent data. Send it before shutting off?	Press YES to send unsent data and turn the HC off. Press NO to turn the HC off and lose the unsent data.
Too few data bytes received	Command returns fewer data bytes than expected as determined by the device description.
Transmitter Fault	Device returns a command response indicating a fault with the connected device.
Units for <variable label> has changed. Unit must be sent before editing, or invalid data will be sent.	The engineering units for this variable have been edited. Send engineering units to the device before editing this variable.
Unsent data to online device. SEND or LOSE data	There is unsent data for a previously connected device which must be sent or thrown away before connecting to another device.
Upgrade 275 software to access XMTR function. Continue with old description?	The communicator does not contain the most recent 3051 Device Descriptors (DDs). Select YES to communicate using the existing DDs. Select NO to abort communication.
Use up/down arrows to change contrast. Press DONE when done.	Gives direction to change the contrast of the HC display.
Value out of range	The user-entered value is either not within the range for the given type and size of variable or not within the min/max specified by the device.
<message> occurred reading/writing <variable label>	Either a read/write command indicates too few data bytes received, transmitter fault, invalid response code, invalid response command, invalid reply data field, or failed pre- or post-read method; or a response code of any class other than SUCCESS is returned reading a particular variable.
<variable label> has an unknown value. Unit must be sent before editing, or invalid data will be sent.	A variable related to this variable has been edited. Send related variable to the device before editing this variable.

5.4 Disassembly procedures

⚠ Do not remove the instrument cover in explosive atmospheres when the circuit is live.

5.4.1 Remove from service

Follow these steps:

- Follow all plant safety rules and procedures.
- Isolate and vent the process from the transmitter before removing the transmitter from service.
- Remove all electrical leads and disconnect conduit.
- Remove the transmitter from the process connection.
- The Rosemount 3051C transmitter is attached to the process connection by four bolts and two cap screws. Remove the bolts and separate the transmitter from the process connection. Leave the process connection in place and ready for re-installation.
- The Rosemount 3051T transmitter is attached to the process by a single hex nut process connection. Loosen the hex nut to separate the transmitter from the process. Do not wrench on neck of transmitter.
- Do not scratch, puncture, or depress the isolating diaphragms.
- Clean isolating diaphragms with a soft rag and a mild cleaning solution, and rinse with clear water.
- For the 3051C, whenever you remove the process flange or flange adapters, visually inspect the PTFE o-rings. Replace the o-rings if they show any signs of damage, such as nicks or cuts. Undamaged o-rings may be reused.

5.4.2 Remove terminal block

Electrical connections are located on the terminal block in the compartment labeled "FIELD TERMINALS."

1. Remove the housing cover from the field terminal side.
2. Loosen the two small screws located on the assembly in the 9 o'clock and 5 o'clock positions.
3. Pull the entire terminal block out to remove it.

5.4.3 Remove the electronics board

The transmitter electronics board is located in the compartment opposite the terminal side. To remove the electronics board perform the following procedure:

1. Remove the housing cover opposite the field terminal side.
2. If you are disassembling a transmitter with a LCD display, loosen the two captive screws that are visible on the right and left side of the meter display.
3. ⚠ Loosen the two captive screws that anchor the board to the housing. The electronics board is electrostatically sensitive; observe handling precautions for static-sensitive components. Use caution when removing the LCD as there is an electronic pin connector that interfaces between the LCD and electronics board. The two screws anchor the LCD display to the electronics board and the electronics board to the housing.
4. Using the two captive screws, slowly pull the electronics board out of the housing. The sensor module ribbon cable holds the electronics board to the housing. Disengage the ribbon cable by pushing the connector release.

5.4.4 Remove the sensor module from the electronics housing

1. Remove the electronics board. Refer to "Remove the electronics board" on page 99.

Important
To prevent damage to the sensor module ribbon cable, disconnect it from the electronics board before you remove the sensor module from the electrical housing.

2. Carefully tuck the cable connector completely inside of the internal black cap.

⚠ See "Safety messages" on page 89 for complete warning

Note
Do not remove the housing until after you tuck the cable connector completely inside of the internal black cap. The black cap protects the ribbon cable from damage that can occur when you rotate the housing.

3. Loosen the housing rotation set screw with a 5/64-inch hex wrench, and loosen one full turn.

4. Unscrew the module from the housing, making sure the black cap and sensor cable do not catch on the housing.

5.5 Reassembly procedures

1. Inspect all cover and housing (non-process wetted) O-rings and replace if necessary. Lightly grease with silicone lubricant to ensure a good seal.

2. Carefully tuck the cable connector completely inside the internal black cap. To do so, turn the black cap and cable counterclockwise one rotation to tighten the cable.

3. Lower the electronics housing onto the module. Guide the internal black cap and cable through the housing and into the external black cap.

4. Turn the module clockwise into the housing.

Important
Make sure the sensor ribbon cable and internal black cap remain completely free of the housing as you rotate it. Damage can occur to the cable if the internal black cap and ribbon cable become hung up and rotate with the housing.

⚠ 5. Thread the housing completely onto the sensor module. The housing must be no more than one full turn from flush with the sensor module to comply with explosion proof requirements.

6. Tighten the housing rotation set screw using a 5/64-inch hex wrench.

5.5.1 Attach the electronics board

1. Remove the cable connector from its position inside of the internal black cap and attach it to the electronics board.

2. Using the two captive screws as handles, insert the electronics board into the housing. Make sure the posts from the electronics housing properly engage the receptacles on the electronics board. Do not force. The electronics board should slide gently on the connections.

3. Tighten the captive mounting screws.

⚠ 4. Replace the electronics housing cover. The transmitter covers must be engaged metal-to-metal to ensure a proper seal and to meet Explosion-Proof requirements.

⚠ See "Safety messages" on page 89 for complete warning

5.5.2 Install the terminal block

1. Gently slide the terminal block into place, making sure the two posts from the electronics housing properly engage the receptacles on the terminal block.

2. Tighten the captive screws.

3. Replace the electronics housing cover. The transmitter covers must be fully engaged to meet Explosion-Proof requirements.

5.5.3 Reassemble the 3051C process flange

1. Inspect the sensor module PTFE o-rings. Undamaged o-rings may be reused. Replace o-rings that show any signs of damage, such as nicks, cuts, or general wear.

Note
If you are replacing the o-rings, be careful not to scratch the o-ring grooves or the surface of the isolating diaphragm when removing the damaged o-rings.

2. Install the process connection. Possible options include:
   a. Coplanar Process Flange:
      – Hold the process flange in place by installing the two alignment screws to finger tightness (screws are not pressure retaining). Do not overtighten as this will affect module-to-flange alignment.
      – Install the four 1.75-in. flange bolts by finger tightening them to the flange.
   b. Coplanar Process Flange with Flange Adapters:
      – Hold the process flange in place by installing the two alignment screws to finger tightness (screws are not pressure retaining). Do not overtighten as this will affect module-to-flange alignment.
      – Hold the flange adapters and adapter o-rings in place while installing the four configurations, use four 2.88-in. bolts. For gage pressure configurations, use two 2.88-in. bolts and two 1.75-in. bolts.
   c. Manifold:
      – Contact the manifold manufacturer for the appropriate bolts and procedures.

3. Tighten the bolts to the initial torque value using a crossed pattern. See Table 5-3 for appropriate torque values.

Table 5-3. Bolt installation torque values

Bolt material	Initial torque value	Final torque value
CS-ASTM-A445 Standard	300 in-lb. (34 N-m)	650 in-lb. (73 N-m)
316 SST—Option L4	150 in-lb. (17 N-m)	300 in-lb. (34 N-m)
ASTM-A-19 B7M—Option L5	300 in-lb. (34 N-m)	650 in-lb. (73 N-m)
ASTM-A-193 Class 2, Grade B8M—Option L8	150 in.-lb (17 N-m)	300 in.-lb (34 N-m)

Note
If you replaced the PTFE sensor module o-rings, re-torque the flange bolts after installation to compensate for cold flow.

Note
After replacing o-rings on Range 1 transmitters and re-installing the process flange, expose the transmitter to a temperature of 185 °F (85 °C) for two hours. Then re-tighten the flange bolts in a cross pattern, and again expose the transmitter to a temperature of 185 °F (85 °C) for two hours before calibration.

5.5.4 Install the drain/vent valve

1. Apply sealing tape to the threads on the seat. Starting at the base of the valve with the threaded end pointing toward the installer, apply two clockwise turns of sealing tape.
2. Tighten the drain/vent valve to 250 in-lb. (28.25 N-m).
3. Take care to place the opening on the valve so that process fluid will drain toward the ground and away from human contact when the valve is opened.

Appendix A Specifications and reference data

A.1 Performance specifications

This product data sheet covers both HART and fieldbus protocols unless specified.

A.1.1 Conformance to specification (±3σ (Sigma))

Technology leadership, advanced manufacturing techniques and statistical process control ensure specification conformance to at least ±3σ.

A.1.2 Reference accuracy[1]

Models[1]	Standard	High Accuracy Option
3051CD, 3051CG Range 0 (CD)	±0.10% of span For spans less than 2:1, accuracy = ±0.05% of URL	
Range 1	±0.10% of span For spans less than 15:1, accuracy = $\pm\left[0.025 + 0.005\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span	
Ranges 2-5	±0.065% of span For spans less than 10:1, accuracy = $\pm\left[0.015 + 0.005\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span	Ranges 2-4 High Accuracy Option, P8 ±0.04% of span For spans less than 5:1, accuracy = $\pm\left[0.015 + 0.005\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span
3051T Ranges 1-4	±0.065% of span For spans less than 10:1, accuracy = $\pm\left[0.0075\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span	Ranges 1-4 High Accuracy Option, P8 ±0.04% of span For spans less than 5:1, accuracy = $\pm\left[0.0075\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span
Range 5	±0.075% of span	
3051CA Ranges 1-4	±0.065% of span For spans less than 10:1, accuracy = $\pm\left[0.0075\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span	Ranges 2-4 High Accuracy Option, P8 ±0.04% of span For spans less than 5:1, accuracy = $\pm\left[0.0075\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span
3051H/3051L All Ranges	±0.075% of span For spans less than 10:1, accuracy = $\pm\left[0.025 + 0.005\left(\frac{\text{URL}}{\text{Span}}\right)\right]$% of Span	

(1) Total performance is determined by performing a root sum square calculation on reference accuracy, ambient temperature effect, and line pressure effect errors. For FOUNDATION fieldbus transmitters, use calibrated range in place of span. For zero based spans, reference conditions, silicone oil fill, SST materials, Coplanar flange (3051C) or 1/2 in. - 18 NPT (3051T) process connections, digital trim values set to equal range points.

A.1.3 Total performance

For ±50 °F (28 °C) temperature changes, up to 1000 psi (6,9 MPa) line pressure (CD only), from 1:1 to 5:1 rangedown.

Models	Total Performance
3051C Ranges 2-5	±0.15% of span
3051T Ranges 1-4	±0.15% of span

A.1.4 Long term stability

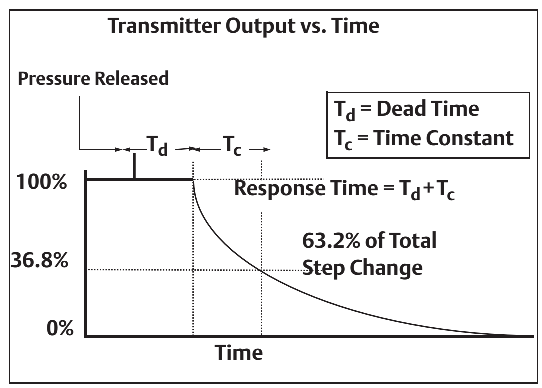
Models	Long Term Stability
3051C Ranges 2-5	±0.125% of URL for 5 years ±50 °F (28 °C) temperature changes, and up to 1000 psi (6,9 MPa) line pressure.
3051CD Low/Draft Range Ranges 0-1	±0.2% of URL for 1 year
3051T Ranges 1-4	±0.125% of URL for 5 years ±50 °F (28 °C) temperature changes, and up to 1000 psi (6,9 MPa) line pressure.
Rosemount 3051H Ranges 2-3 Ranges 4-5	±0.1% of URL for 1 year ±0.2% of URL for 1 year

A.1.5 Dynamic performance

	4 - 20 mA (*HART* protocol)(1)	Fieldbus protocol(3)
Total Response Time ($T_d + T_c$)(2):		
3051C, Ranges 2-5: Range 1: Range 0: 3051T: 3051H/L:	100 ms 255 ms 700 ms 100 ms Consult factory	152 ms 307 ms 752 ms 152 ms Consult factory
Dead Time (Td)	45 ms (nominal)	97 ms
Update Rate	22 times per second	22 times per second

(1) Dead time and update rate apply to all models and ranges; analog output only
(2) Nominal total response time at 75 °F (24 °C) reference conditions.
(3) Transmitter fieldbus output only, segment macro-cycle not included.

Typical HART Transmitter Response Time



A.1.6 Line pressure effect per 1000 psi (6,9 MPa)(1)

Models(1)	Line Pressure Effect
3051CD	Zero Error(2)
Range 0	±0.125% of URL/100 psi (6,89 bar)
Range 1	±0.25% of URL/1000 psi (68,9 bar)
Ranges 2-3	±0.05% of URL/1000 psi (68,9 bar) for line pressures from 0 to 2000 psi (0 to 13,7 MPa)
	Span Error
Range 0	±0.15% of reading/100 psi (6,89 bar)
Range 1	±0.4% of reading/1000 psi (68,9 bar)
Ranges 2-3	±0.1% of reading/1000 psi (68,9 bar)

Models[1]	Line Pressure Effect
3051HD All Ranges	Zero Error[1] ±0.1% of URL/1000 psi (68,9 bar) for line pressures from 0 to 2000 psi (0 to 13,7 MPa)
All Ranges	Span Error ±0.1% of reading/1000 psi (68,9 bar)

(1) For zero error specifications for line pressures above 2000 psi (137,9 bar) or line pressure effect specifications for DP Ranges 4-5, see "Compensating for Line Pressure" on page 13.
(2) Can be calibrated out at line pressure.

A.1.7 Ambient temperature effect per 50 °F (28 °C)

Models	Ambient Temperature Effect
3051CD/CG Range 0	±(0.25% URL + 0.05% span)
Range 1	±(0.1% URL + 0.25% span)
Ranges 2-5	±(0.0125% URL + 0.0625% span) from 1:1 to 5:1 ±(0.025% URL + 0.125% span) from 5:1 to 100:1
3051T Range 1	±(0.025% URL + 0.125% span) from 1:1 to 10:1 ±(0.05% URL + 0.125% span) from 10:1 to 100:1
Range 2-4	±(0.025% URL + 0.125% span) from 1:1 to 30:1 ±(0.035% URL + 0.125% span) from 30:1 to 100:1
Range 5	±(0.1% URL + 0.15% span)
3051CA All Ranges	±(0.025% URL + 0.125% span) from 1:1 to 30:1
	±(0.035% URL + 0.125% span) from 30:1 to 100:1
3051H All Ranges	±(0.025% URL + 0.125% span + 0.35 inH_2O) from 1:1 to 30:1
	±(0.035% URL + 0.125% span + 0.35 inH_2O) from 1:1 to 30:1
3051L	See Rosemount Inc. Instrument Toolkit® software.

A.1.8 Mounting position effects

Models	Mounting Position Effects
3051C	Zero shifts up to ±1.25 inH_2O (3,11 mbar), which can be calibrated out. No span effect.
3051H	Zero shifts up to ±5 inH_2O (12,43 mbar), which can be calibrated out. No span effect.
3051L	With liquid level diaphragm in vertical plane, zero shift of up to 1 inH_2O (2,49 mbar). With diaphragm in horizontal plane, zero shift of up to 5 inH_2O (12,43 mbar) plus extension length on extended units. All zero shifts can be calibrated out. No span effect.
3051T/CA	Zero shifts up to 2.5 inH_2O (6,22 mbar), which can be calibrated out. No span effect.

A.1.9 Vibration effect

Less than ±0.1% of URL when tested per the requirements of IEC60770-1 field or pipeline with high vibration level (10-60 Hz 0.21mm displacement peak amplitude / 60-2000 Hz 3g).

A.1.10 Power supply effect

Less than ±0.005% of calibrated span per volt.

A.1.11 Electromagnetic compatibility (EMC)

Meets all relevant requirements of EN 61326 and NAMUR NE-21.

A.1.12 Transient protection (option code T1)

Meets IEEE C62.41, Category Location B

6 kV crest (0.5 μs - 100 kHz)
3 kV crest (8 × 20 microseconds)
6 kV crest (1.2 × 50 microseconds)

A.2 Functional specifications

A.2.1 Range and sensor limits

Table A-1. 3051CD, 3051CG, 3051L, and 3051H range and sensor limits

Range	Minimum span	
	3051CD[(1)], CG, L, H	Upper (URL)
0	0.1 inH2O (0,25 mbar)	3.0 inH2O(7,47 mbar)
1	0.5 inH2O (1,2 mbar)	25 inH2O(62,3 mbar)
2	2.5 inH2O (6,2 mbar)	250 inH2O (0,62 bar)
3	10 inH2O (24,9 mbar)	1000 inH2O (2,49 bar)
4	3 psi (0,20 bar)	300 psi (20,6 bar)
5	20 psi (1,38 bar)	2000 psi (137,9 bar)

(1) Range 0 only available with 3051CD. Range 1 only available with 3051CD or 3051CG.

Table A-2. 3051CD, 3051CG, 3051L, and 3051H range and sensor limits (cont.)

Range	Range and sensor limits					
	Lower (LRL)					
	3051C differential	3051C/ gage	3051L differential	3051L gage	3051H differential	3051H gage
0	–3.0 inH2O (-7,47 mbar)	NA	NA	NA	NA	NA
1	–25 inH2O (–62,1 mbar)	–25 inH2O (–62,1 mbar)	NA	NA	NA	NA
2	–250 inH2O (–0,62 bar)	–250 inH2O (–0,62 bar)	–250 inH2O (–0,62 bar)	–250 inH2O (–0,62 bar)	–250 inH2O (–0,62 bar)	–250 inH2O (–0,62 bar)
3	–1000 inH2O (–2,49 bar)	0.5 psia (34,5 mbar abs)	–1000 inH2O (–2,49 bar)	0.5 psia (34,5 mbar abs)	–1000 inH2O (–2,49 bar)	0.5 psia (34,5 mbar abs)
4	–300 psi (–20,6 bar)	0.5 psia (34,5 mbar abs)	–300 psi (–20,6 bar)	0.5 psia (34,5 mbar abs)	–300 psi (–20,6 bar)	0.5 psia (34,5 mbar abs)
5	– 2000 psi (–137,9 bar)	0.5 psia (34,5 mbar abs)	NA	NA	– 2000 psi (–137,9 bar)	0.5 psia (34,5 mbar abs)

Table A-3. Range and sensor limits

3051CA					3051T				
Range	Minimum span	Range and sensor limits			Range	Minimum span	Range and sensor limits		Lower[(1)] (LRL) (Gage)
		Upper (URL)	Lower (LRL)				Upper (URL)	Lower (LRL)	
1	0.3 psia (20,6 mbar)	30 psia (2,07 bar)	0 psia (0 bar)		1	0.3 psi (20,6 mbar)	30 psi (2,07 bar)	0 psia (0 bar)	–14.7 psig (–1,01 bar)
2	1.5 psia (0,103 bar)	150 psia (10,3 bar)	0 psia (0 bar)		2	1.5 psi (0,103 bar)	150 psi (10,3 bar)	0 psia (0 bar)	–14.7 psig (–1,01 bar)
3	8 psia (0,55 bar)	800 psia (55,2 bar)	0 psia (0 bar)		3	8 psi (0,55 bar)	800 psi (55,2 bar)	0 psia (0 bar)	–14.7 psig (–1,01 bar)
4	40 psia (2,76 bar)	4000 psia (275,8 bar)	0 psia (0 bar)		4	40 psi (2,76 bar)	4000 psi (275,8 bar)	0 psia (0 bar)	–14.7 psig (–1,01 bar)
					5	2000 psi (137,9 bar)	10000 psi (689,4 bar)	0 psia (0 bar)	–14.7 psig (–1,01 bar)

(1) *Assumes atmospheric pressure of 14.7 psig.*

A.2.2 Zero and Span Adjustment Requirements (*HART* and Low Power)

Zero and span values can be set anywhere within the range limits stated in Table A-1, Table A-2, and Table A-3.

Span must be greater than or equal to the minimum span stated in Table A-1, Table A-2, and Table A-3.

A.2.3 Service

Liquid, gas, and vapor applications

A.2.4 4–20 mA (Output Code A)

Output

Two-wire 4–20 mA, user-selectable for linear or square root output. Digital process variable superimposed on 4–20 mA signal, available to any host that conforms to the *HART* protocol.

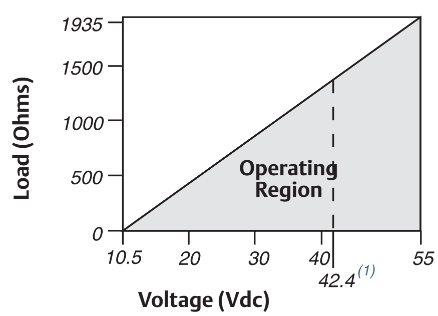
Power Supply

External power supply required. Standard transmitter (4–20 mA) operates on 10.5 to 55 Vdc with no load.

Load Limitations

Maximum loop resistance is determined by the voltage level of the external power supply, as described by:

Max. Loop Resistance = 43.5 (Power Supply Voltage – 10.5)



Communication requires a minimum loop resistance of 250 ohms.

(1) For CSA approval, power supply must not exceed 42.4 V.

A.2.5 FOUNDATION fieldbus (output code F) and Profibus (output code W)

Power Supply

External power supply required; transmitters operate on 9.0 to 32.0 Vdc transmitter terminal voltage.

Current Draw

17.5 mA for all configurations (including LCD display option)

A.2.6 FOUNDATION fieldbus function block execution times

Block	Execution Time
Resource	-
Transducer	-
LCD Block	-
Analog Input 1, 2	30 milliseconds
PID	45 milliseconds
Input Selector	30 milliseconds
Arithmetic	35 milliseconds
Signal Characterizer	40 milliseconds
Integrator	35 milliseconds

A.2.7 FOUNDATION fieldbus Parameters

Schedule Entries	7 (max.)
Links	20 (max.)
Virtual Communications Relationships (VCR)	12 (max.)

A.2.8 Standard Function Blocks

Resource Block

Contains hardware, electronics, and diagnostic information.

Transducer Block

Contains actual sensor measurement data including the sensor diagnostics and the ability to trim the pressure sensor or recall factory defaults.

LCD Block

Configures the local display.

2 Analog Input Blocks

Processes the measurements for input into other function blocks. The output value is in engineering units or custom and contains a status indicating measurement quality.

PID Block

Contains all logic to perform PID control in the field including cascade and feedforward.

A.2.9 Backup Link Active Scheduler (LAS)

The transmitter can function as a Link Active Scheduler if the current link master device fails or is removed from the segment.

A.2.10 Advanced control function block suite (Option Code A01)

Input Selector Block

Selects between inputs and generates an output using specific selection strategies such as minimum, maximum, midpoint, average or first "good."

Arithmetic Block

Provides pre-defined application-based equations including flow with partial density compensation, electronic remote seals, hydrostatic tank gauging, ratio control and others.

Signal Characterizer Block

Characterizes or approximates any function that defines an input/output relationship by configuring up to twenty X, Y coordinates. The block interpolates an output value for a given input value using the curve defined by the configured coordinates.

Integrator Block

Compares the integrated or accumulated value from one or two variables to pre-trip and trip limits and generates discrete output signals when the limits are reached. This block is useful for calculating total flow, total mass, or volume over time.

A.2.11 FOUNDATION fieldbus Diagnostics Suite (Option Code D01)

The 3051C FOUNDATION fieldbus Diagnostics provide Abnormal Situation Prevention (ASP) indictation. The integral statistical process monitoring (SPM) technology calculates the mean and standard deviation of the process variable 22 times per second. The 3051C ASP algorithm uses these values and highly flexible configuration options for customization to many user-defined or application specific abnormal situations. The detection of plugged impulse lines is the first available predefined application.

A.2.12 Low Power (output code M)

Output

Three wire 1–5 Vdc or 0.8–3.2 Vdc (Option Code C2) user-selectable output. Also user selectable for linear or square root output configuration. Digital process variable superimposed on voltage signal, available to any host conforming to the *HART* protocol. Low-power transmitter operates on 6–14 Vdc with no load.

Power Consumption

3.0 mA, 18–36 mW

Minimum Load Impedance

100 kΩ (V_{out} wiring)

Indication

Optional 5-digit LCD display

Overpressure Limits

Rosemount 3051CD/CG

- Range 0: 750 psi (51,7 bar)
- Range 1: 2000 psig (137,9 bar)
- Ranges 2–5: 3626 psig (250 bar)
  4500 psig (310,3 bar) for option code P9

Rosemount 3051CA

- Range 1: 750 psia (51,7 bar)
- Range 2: 1500 psia (103,4 bar)
- Range 3: 1600 psia (110,3 bar)
- Range 4: 6000 psia (413,7 bar)

Rosemount 3051H

- All Ranges: 3626 psig (25 MPa)

Rosemount 3051TG/TA

- Range 1: 750 psi (51,7 bar)
- Range 2: 1500 psi (103,4 bar)
- Range 3: 1600 psi (110,3 bar)
- Range 4: 6000 psi (413,7 bar)
- Range 5: 15000 psi (1034,2 bar)

For 3051L or Level Flange Option Codes FA, FB, FC, FD, FP, and FQ, limit is 0 psia to the flange rating or sensor rating, whichever is lower.

Table A-4. 3051L and level flange rating limits

Standard	Type	CS rating	SST rating
ANSI/ASME	Class 150	285 psig	275 psig
ANSI/ASME	Class 300	740 psig	720 psig
ANSI/ASME	Class 600	1480 psig	1440 psig
At 100 °F (38 °C), the rating decreases with increasing temperature.			
DIN	PN 10–40	40 bar	40 bar
DIN	PN 10/16	16 bar	16 bar
DIN	PN 25/40	40 bar	40 bar
At 248 °F (120 °C), the rating decreases with increasing temperature.			

A.2.13 Static Pressure Limit

Rosemount 3051CD Only

Operates within specifications between static line pressures of 0.5 psia and 3626 psig (4500 psig (310, 3 bar) for
Option Code P9).

Range 0: 0.5 psia and 750 psig (3, 4 bar and 51, 7 bar)

Range 1: 0.5 psia and 2000 psig (3, 4 bar and 137, 9 bar)

A.2.14 Burst Pressure Limits

Burst pressure on Coplanar, traditional, or 3051H process flange is 10000 psig (69 MPa).

Burst pressure for the 3051T is:

Ranges 1–4: 11000 psi (75,8 MPa)

Range 5: 26000 psig (179 MPa)

A.2.15 Failure Mode Alarm

Output Code A

If self-diagnostics detect a gross transmitter failure, the analog signal will be driven either below 3.75 mA or to 21.75 mA to alert the user. NAMUR-compliant values are available, option code C4. High or low alarm signal is user-selectable by internal jumper.

Output Code M

If self-diagnostics detect a gross transmitter failure, the analog signal will be driven either below 0.94 V or above 5.4 V to alert the user (below 0.75 V or above 4.4 V for Option C2). High or low alarm signal is user-selectable by internal jumper.

Output Code F and W

If self-diagnostics detect a gross transmitter failure, that information gets passed as a status along with the process variable.

A.2.16 Temperature Limits

Ambient

–40 to 185 °F (–40 to 85 °C)

With LCD display(1): –40 to 175 °F (–40 to 80 °C)

Storage

–50 to 230 °F (–46 to 110 °C)

With LCD display: –40 to 185 °F (–40 to 85 °C)

Process

At atmospheric pressures and above. See Table A-5

(1) LCD display may not be readable and LCD updates will be slower at temperatures below -4 °F (-20 °C).

Table A-5. 3051 process temperature limits

3051CD, 3051CG, 3051CA	
Silicone Fill Sensor(1)	
with Coplanar Flange	–40 to 250 °F (–40 to 121 °C)(2)
with Traditional Flange	–40 to 300 °F (–40 to 149 °C)(2)(3)
with Level Flange	–40 to 300 °F (–40 to 149 °C)(2)
with 305 Integral Manifold	–40 to 300 °F (–40 to 149 °C)(2)
Inert Fill Sensor(1)	-40 to 185 °F (–40 to 85 °C)(4)(5)
3051H (process fill fluid)	
D.C.® Silicone 200(1)	–40 to 375 °F (–40 to 191 °C)
Inert(1)	–50 to 350 °F (–45 to 177 °C)
Neobee M-20®(1)	0 to 375 °F (–18 to 191 °C)
3051T (process fill fluid)	
Silicone Fill Sensor(1)	–40 to 250 °F (–40 to 121 °C)(2)
Inert Fill Sensor(1)	–22 to 250 °F (–30 to 121 °C)(2)
3051L low-side temperature limits	
Silicone Fill Sensor(1)	–40 to 250 °F (–40 to 121 °C)(2)
Inert Fill Sensor(1)	0 to 185 °F (–18 to 85 °C)(2)

3051L high-side temperature limits (process fill fluid)	
Syltherm® XLT	–100 to 300 °F (–73 to 149 °C)
D.C. Silicone 704®	32 to 400 °F (0 to 205 °C)
D.C. Silicone 200	–40 to 400 °F (–40 to 205 °C)
Inert	–50 to 350 °F (–45 to 177 °C)
Glycerin and Water	0 to 200 °F (–18 to 93 °C)
Neobee M-20	0 to 400 °F (–18 to 205 °C)
Propylene Glycol and Water	0 to 200 °F (–18 to 93 °C)

(1) Process temperatures above 185 °F (85 °C) require derating the ambient limits by a 1.5:1 ratio (0.6:1 ratio for the 3051H).
(2) 220 °F (104 °C) limit in vacuum service; 130 °F (54 °C) for pressures below 0.5 psia.
(3) 3051CD0 process temperature limits are –40 to 212 °F (–45 to 100 °C)
(4) 160 °F (71 °C) limit in vacuum service.
(5) Not available for 3051CA.

Humidity Limits

0–100% relative humidity

Turn-On Time

Performance within specifications less than 2.0 seconds (10.0 s for Profibus protocol) after power is applied to the transmitter

Volumetric Displacement

Less than 0.005 in^3 (0,08 cm^3)

Damping

Analog output response to a step input change is user-selectable from 0 to 36 seconds for one time constant. This software damping is in addition to sensor module response time.

A.3 Physical specifications

A.3.1 Electrical Connections

$^1/_2$–14 NPT, G$^1/_2$, and M20 × 1.5 (CM20) conduit. HART interface connections fixed to terminal block.

A.3.2 Process Connections

All Models except 3051L and 3051T

$^1/_4$–18 NPT on 2$^1/_8$-in. centers

$^1/_2$–14 NPT on 2-, 2$^1/_8$-, or 2$^1/_4$-in. centers

Rosemount 3051L

High pressure side: 2-, 3-, or 4-in., ASME B 16.5 (ANSI) Class 150, 300 or 600 flange; 50, 80 or 100 mm, PN 40 or 10/16 flange

Low pressure side: $^1/_4$–18 NPT on flange $^1/_2$–14 NPT on adapter

Rosemount 3051T

$^1/_2$–14 NPT female. A DIN 16288 Male (available in SST for Range 1–4 transmitters only), or Autoclave type F-250-C (Pressure relieved $^9/_{16}$–18 gland thread; $^1/_4$ OD high pressure tube 60° cone; available in SST for Range 5 transmitters only).

A.3.3 Process-Wetted Parts

Drain/Vent Valves

316 SST, Alloy C-276, or Alloy 400/K-500(1) material
(Drain vent seat: Alloy 400, Drain vent stem: Alloy K-500)

(1)Alloy 400/K-500 is not available with 3051L or 3051H.

Process Flanges and Adapters

Plated carbon steel
SST: CF-8M (Cast 316 SST) per ASTM A743
Cast C-276: CW-12MW per ASTM A494
Cast Alloy 400: M-30C per ASTM A494

Wetted O-rings

Glass-filled PTFE or Graphite-filled PTFE

Process Isolating Diaphragms

Isolating diaphragm material	3051CD/CG	3051T	3051CA	3051H
316L SST	•	•	•	•
Alloy C-276	•	•	•	•
Alloy 400	•		•	
Tantalum	•			•
Gold-plated Alloy 400	•		•	
Gold-plated SST	•		•	

A.3.4 Rosemount 3051L Process Wetted Parts

Flanged Process Connection (Transmitter High Side)

Process Diaphragms, Including Process Gasket Surface

- 316L SST, Alloy C-276, or Tantalum
- Extension
- CF-3M (Cast version of 316L SST, material per ASTM-A743), or Alloy C-276. Fits schedule 40 and 80 pipe.
- Mounting Flange
- Zinc-cobalt plated CS or SST

Reference Process Connection (Transmitter Low Side)

Isolating Diaphragms

- 316L SST or Alloy C-276

Reference Flange and Adapter

- CF-8M (Cast version of 316 SST, material per ASTM-A743)

A.3.5 Non-Wetted Parts

Electronics Housing

Low copper aluminum or SST: CF-3M or CF-8M (Cast version of 316L or 316 SST, material per ASTM-A743). NEMA 4X, IP 65, IP 66

Coplanar Sensor Module Housing

CF-3M (Cast version of 316L SST, material per ASTM-A743)

Bolts

ASTM A449, Type 1 (zinc-cobalt plated carbon steel)
ASTM F593G, Condition CW1 (Austenitic 316 SST)
ASTM A193, Grade B7M (zinc plated alloy steel)
Alloy 400

Sensor Module Fill Fluid

Silicone oil (D.C. 200) or Fluorocarbon oil (Halocarbon or Fluorinert® FC-43 for 3051T)

Process Fill Fluid (3051L and 3051H only)

3051L: Syltherm XLT, D.C. Silicone 704,
D.C. Silicone 200, inert, glycerin and water, Neobee M-20 or propylene glycol and water

3051H: inert, Neobee M-20, or D.C. Silicone 200

Paint

Polyurethane

Cover O-rings

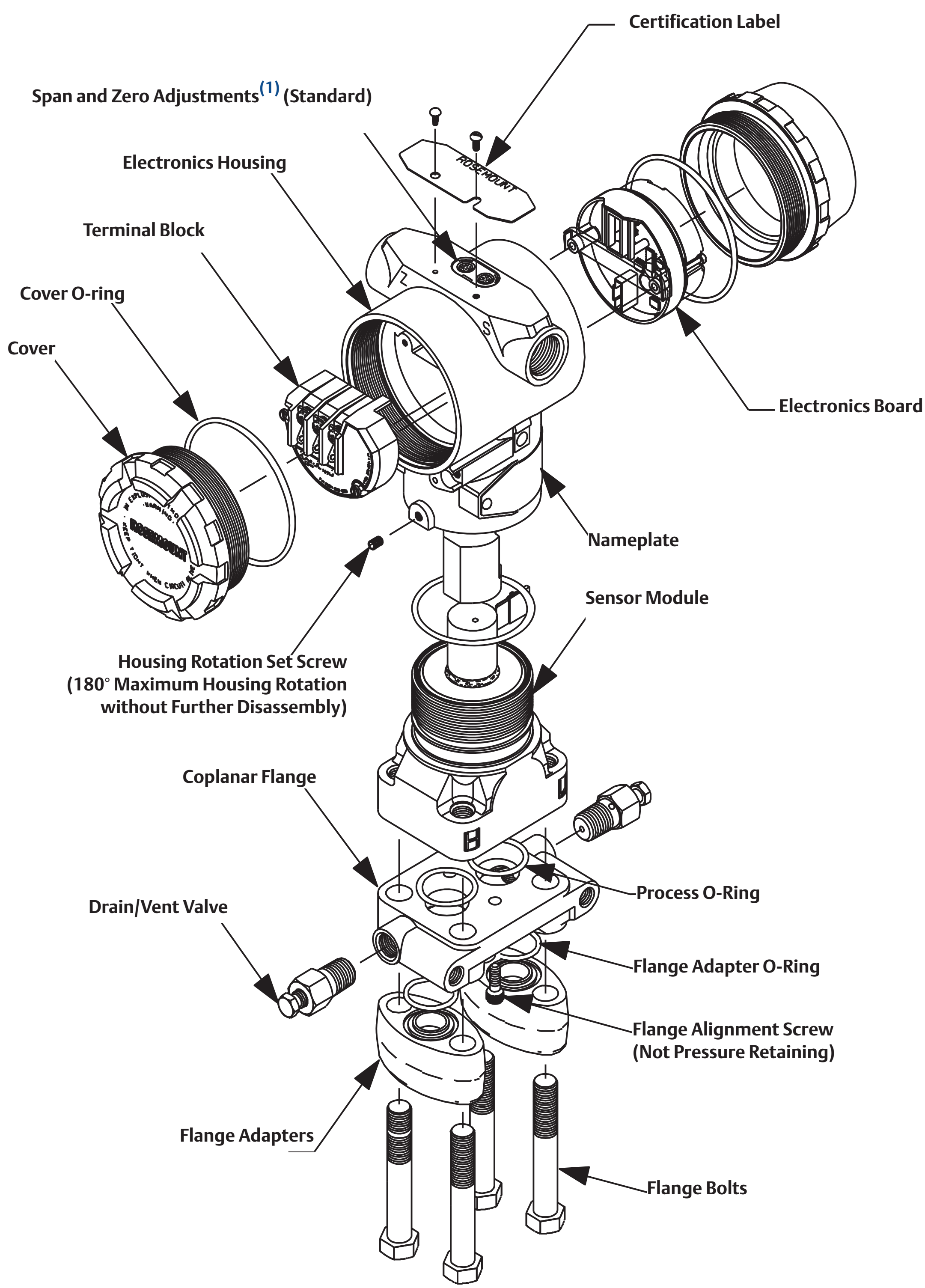
Buna-N

A.3.6 Shipping Weights

Refer to "Shipping weights" on page 159.

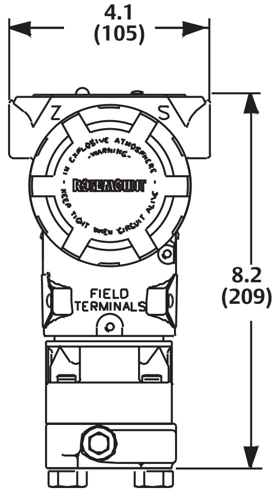
A.4 Dimensional Drawings

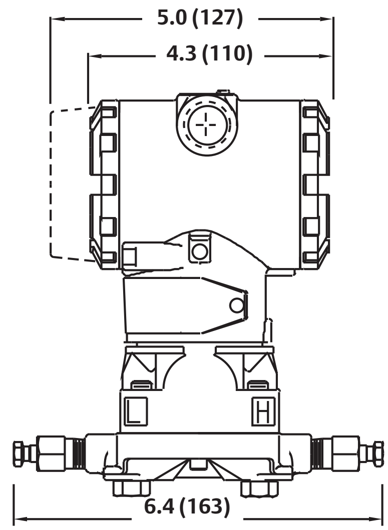
3051 Exploded View



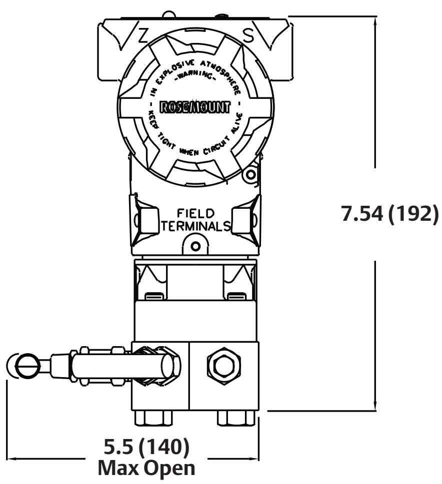
(1) Span and Zero Adjustments are not available with fieldbus or profibus protocols.

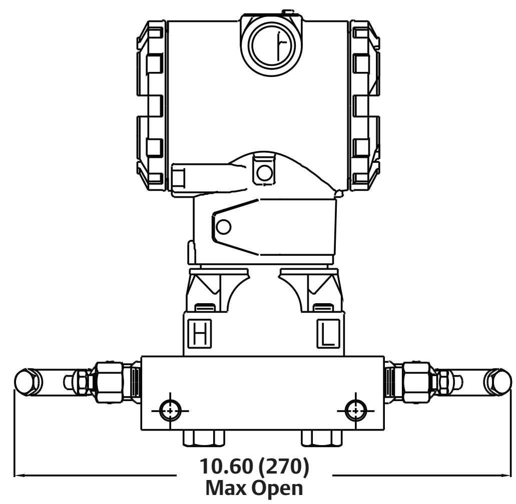
3051C Coplanar Flange



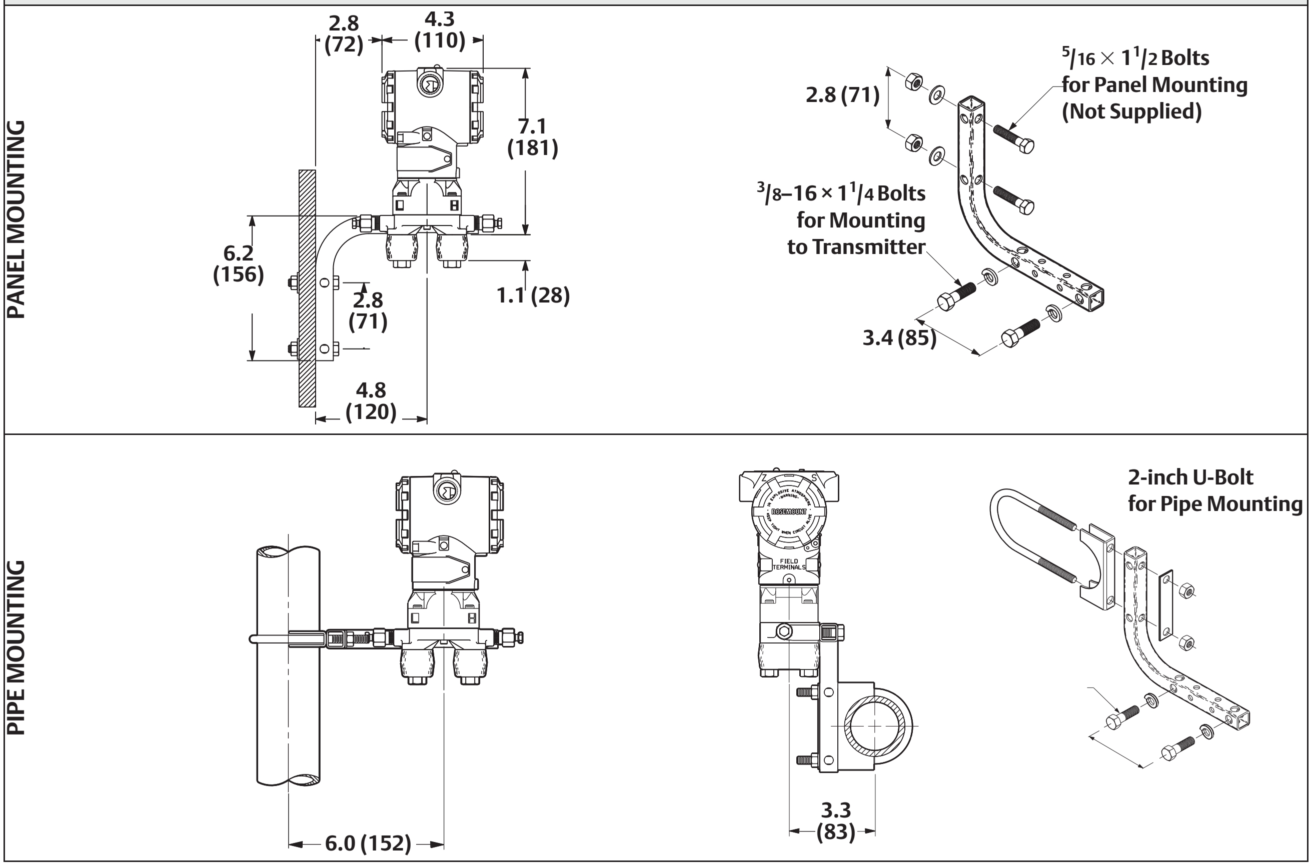


3051C Coplanar Flange with Rosemount 305 Coplanar Integral Manifold



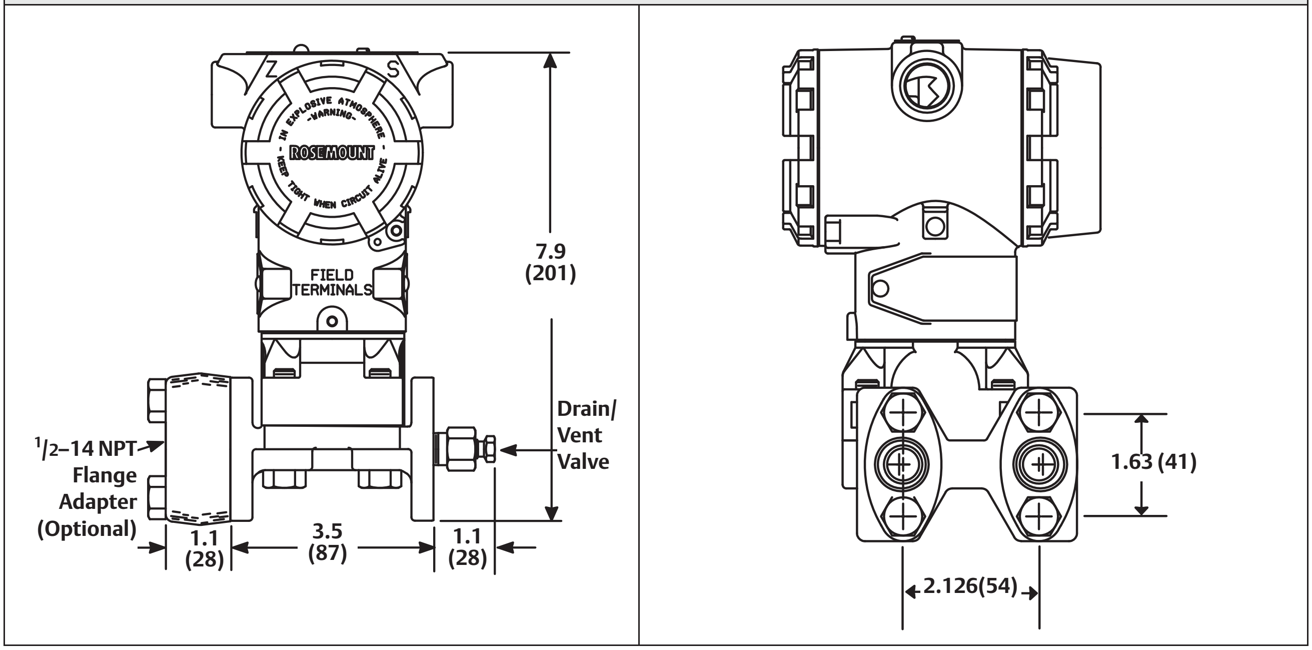


Coplanar Flange Mounting Configurations with Optional Bracket (B4) for 2-in. Pipe or Panel Mounting



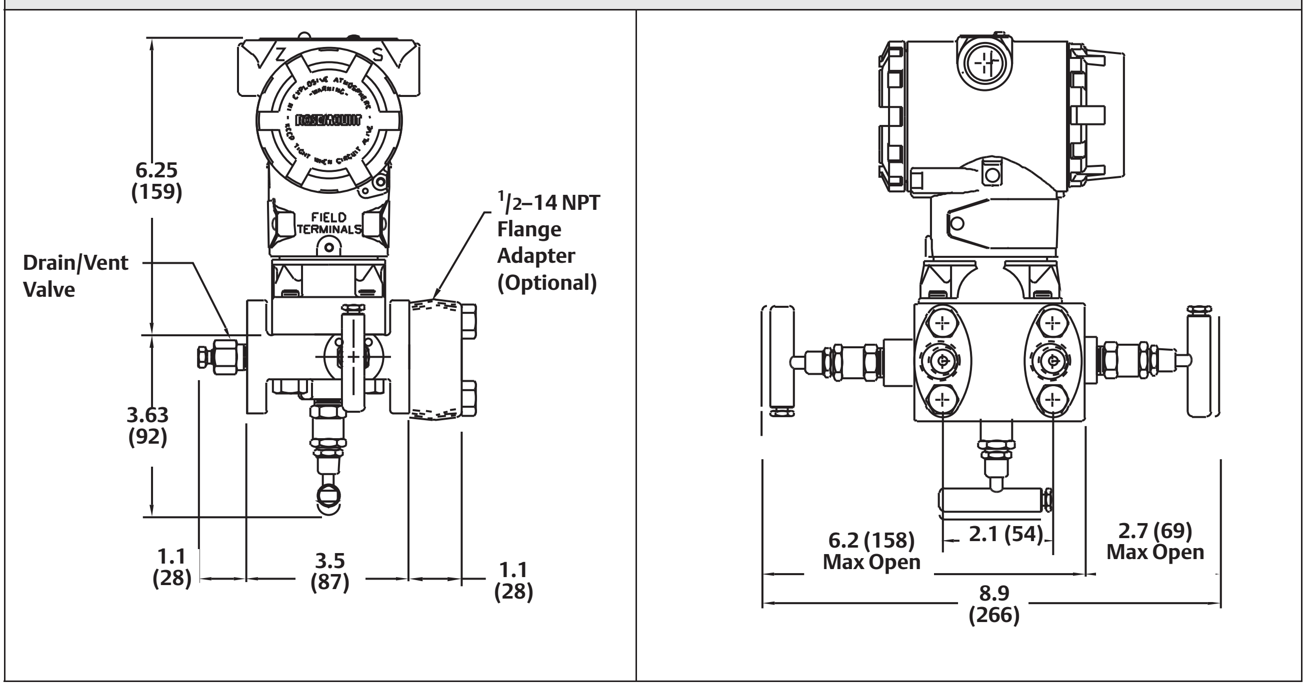
Dimensions are in inches (millimeters)

3051C Coplanar with Traditional Flange



Dimensions are in inches (millimeters)

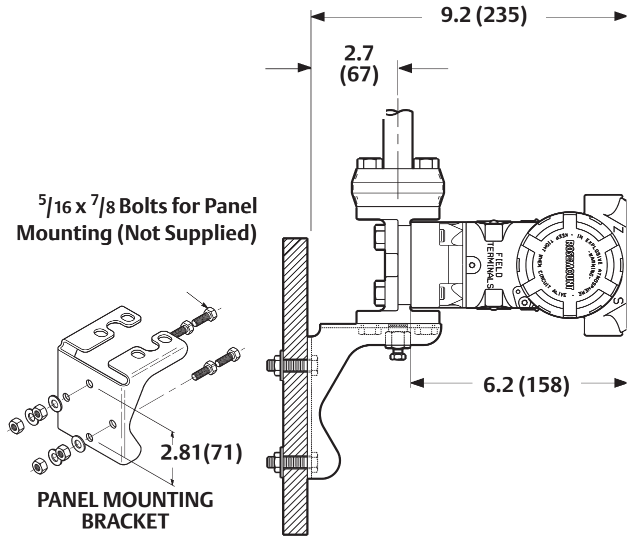
3051C Coplanar with Rosemount 305 Traditional Integral Manifold



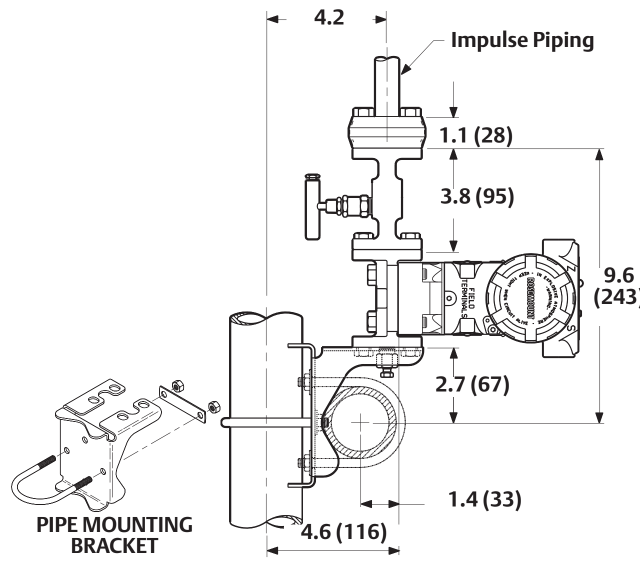
Dimensions are in inches (millimeters)

Traditional Flange Mounting Configurations with Optional Brackets for 2-in. Pipe or Panel Mounting

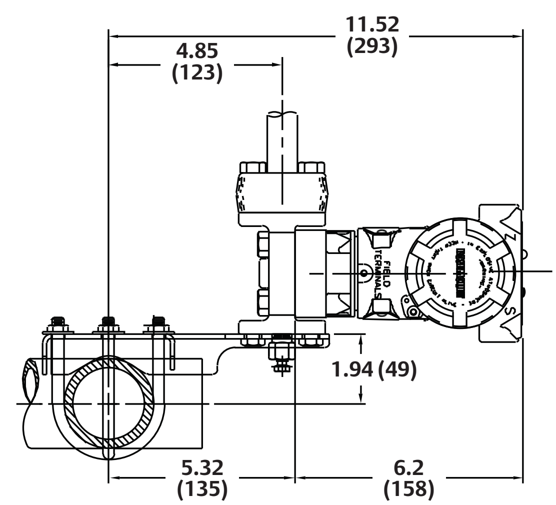
Panel Mounting Bracket (option B2/B8)



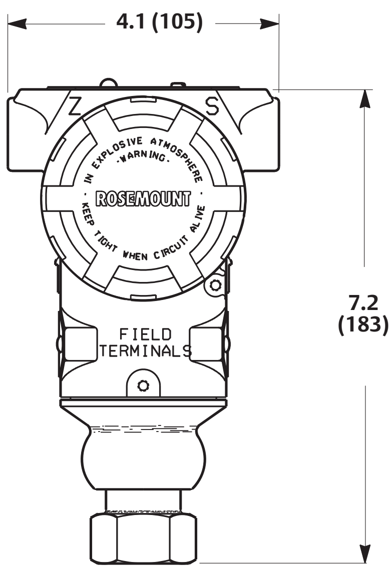
2-in. Pipe Mounting Bracket (option B1/B7/BA)

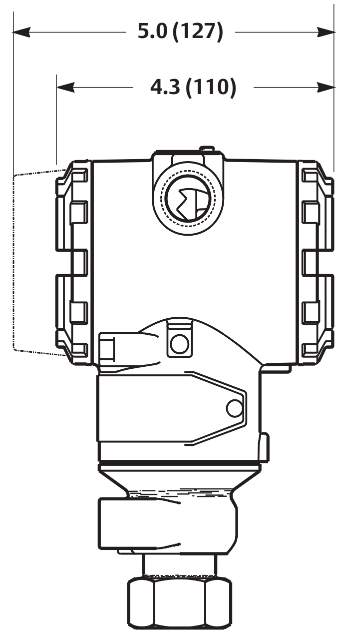


2-in. Pipe Mounting Bracket (option B3/B9/BC)

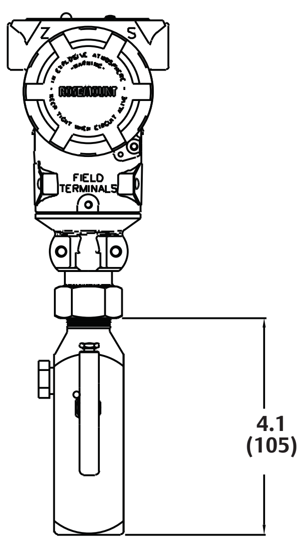


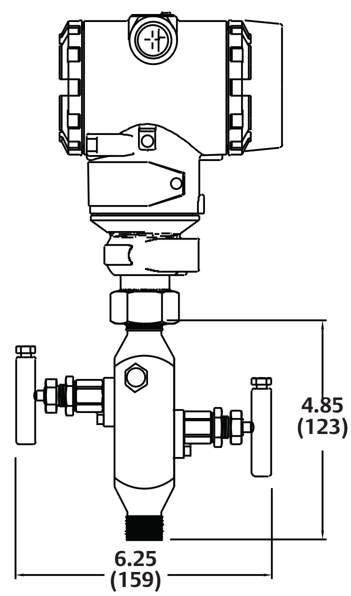
3051T Dimensional Drawings

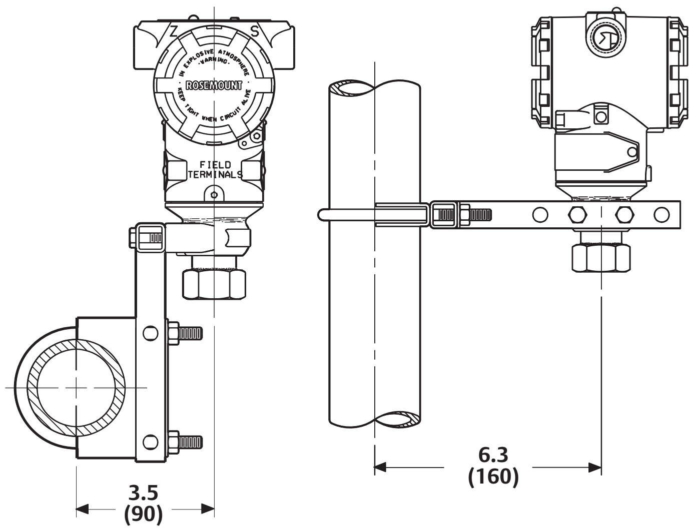
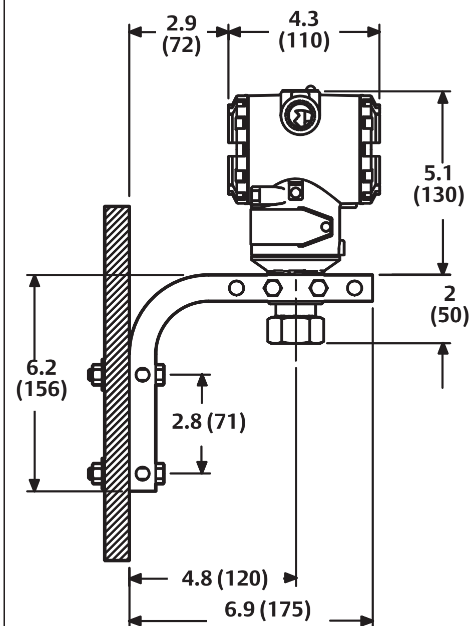




3051T with Rosemount 306 Integral Manifold





<table>
<tr><th colspan="2">3051T Typical Mounting Configurations with Optional Mounting Bracket</th></tr>
<tr><th>Pipe Mounting</th><th>Panel Mounting</th></tr>
<tr><td>
</td><td>
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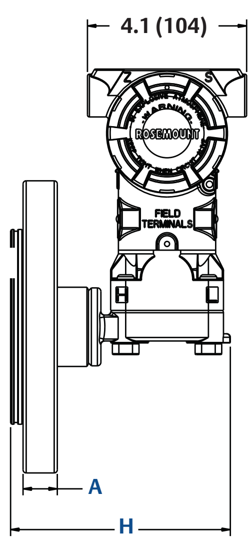
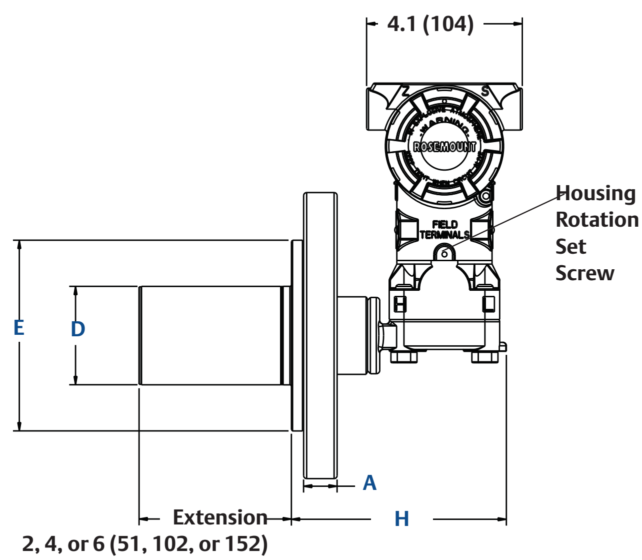
Dimensions are in inches (millimeters)

3051L Dimensional Drawings

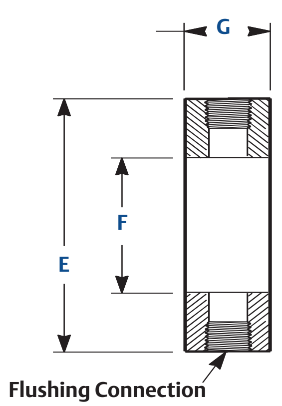
2-in. Flange Configuring (Flush Mount Only)



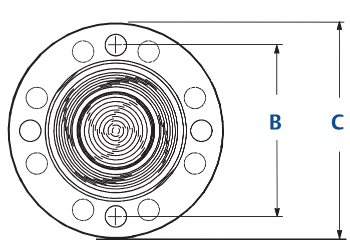
3- and 4-in. Flange Configuration

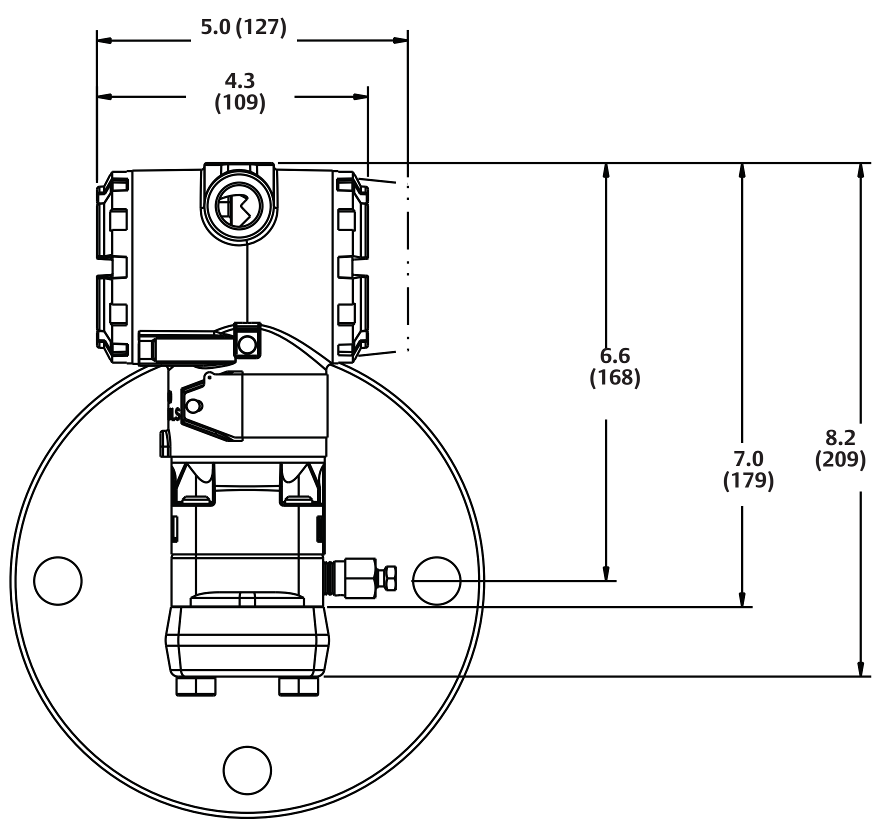


Optional Flushing Connection Ring (Lower Housing)



Diaphragm Assembly and Mounting Flange





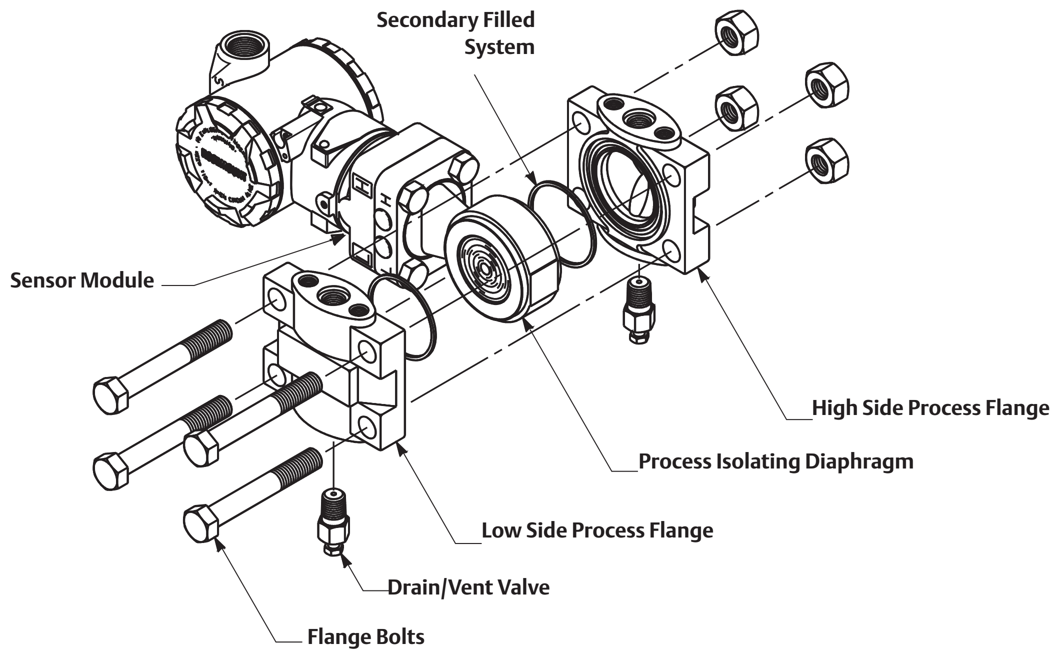
Dimensions are in inches (millimeters)

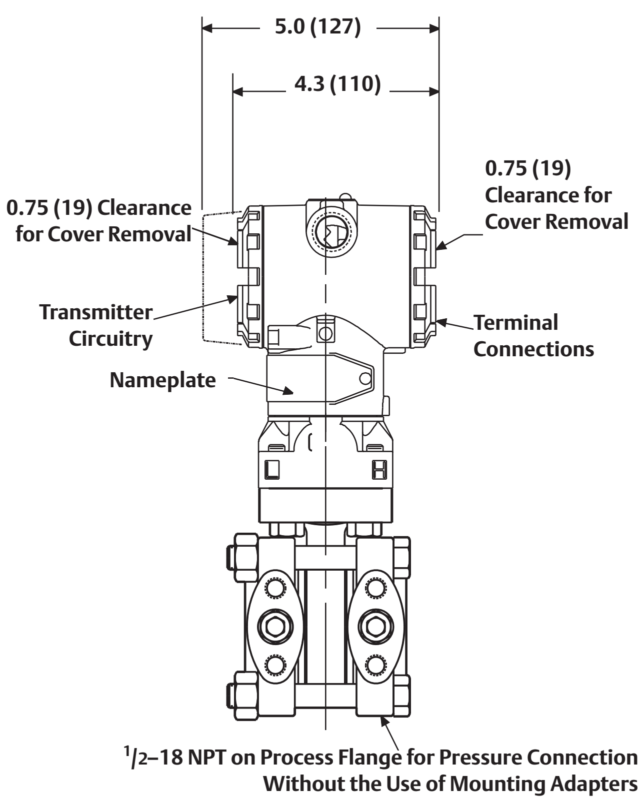
Class	Pipe size	Flange thickness A	Bolt circle diameter B	Outside diameter C	No. of bolts	Bolt hole diameter	Extension diameter[1] D	O.D. gasket surface E
ASME B16.5 (ANSI) 150	2 (51)	0.69 (18)	4.75 (121)	6.0 (152)	4	0.75 (19)	NA	3.6 (92)
	3 (76)	0.88 (22)	6.0 (152)	7.5 (191)	4	0.75 (19)	2.58 (66)	5.0 (127)
	4 (102)	0.88 (22)	7.5 (191)	9.0 (229)	8	0.75 (19)	3.5 (89)	6.2 (158)
ASME B16.5 (ANSI) 300	2 (51)	0.82 (21)	5.0 (127)	6.5 (165)	8	0.75 (19)	NA	3.6 (92)
	3 (76)	1.06 (27)	6.62 (168)	8.25 (210)	8	0.88 (22)	2.58 (66)	5.0 (127)
	4 (102)	1.19 (30)	7.88 (200)	10.0 (254)	8	0.88 (22)	3.5 (89)	6.2 (158)
ASME B16.5 (ANSI) 600	2 (51)	1.00 (25)	5.0 (127)	6.5 (165)	8	0.75 (19)	NA	3.6 (92)
	3 (76)	1.25 (32)	6.62 (168)	8.25 (210)	8	0.88 (22)	2.58 (66)	5.0 (127)
DIN 2501 PN 10–40	DN 50	20 mm	125 mm	165 mm	4	18 mm	NA	4.0 (102)
DIN 2501 PN 25/40	DN 80	24 mm	160 mm	200 mm	8	18 mm	66 mm	5.4 (138)
	DN 100	24 mm	190 mm	235 mm	8	22 mm	89 mm	6.2 (158)
DIN 2501 PN 10/16	DN 100	20 mm	180 mm	220 mm	8	18 mm	89 mm	6.2 (158)

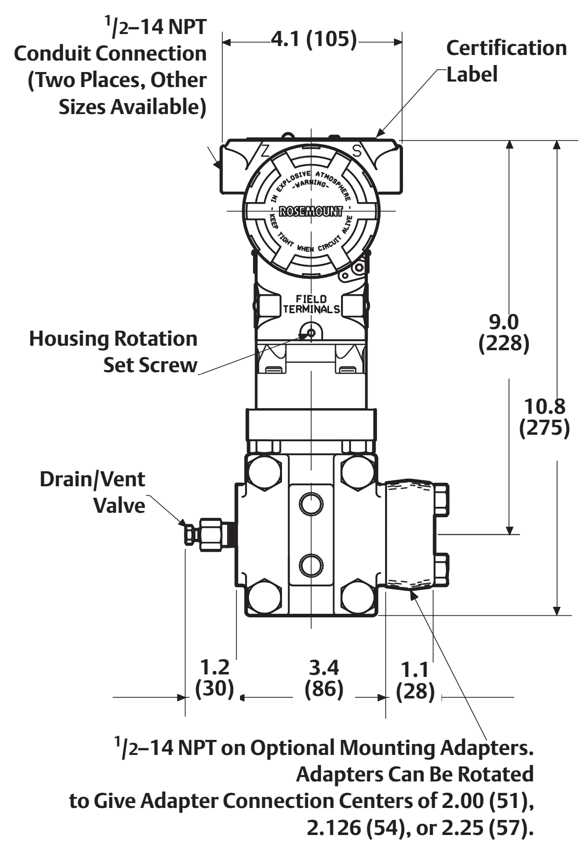
Class	Pipe size	Process side F	Lower housing G		H
			1/4 NPT	1/2 NPT	
ASME B16.5 (ANSI) 150	2 (51)	2.12 (54)	0.97 (25)	1.31 (33)	5.65 (143)
	3 (76)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	4 (102)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
ASME B16.5 (ANSI) 300	2 (51)	2.12 (54)	0.97 (25)	1.31 (33)	5.65 (143)
	3 (76)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	4 (102)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
ASME B16.5 (ANSI) 600	2 (51)	2.12 (54)	0.97 (25)	1.31 (33)	7.65 (194)
	3 (76)	3.6 (91)	0.97 (25)	1.31 (33)	7.65 (194)
DIN 2501 PN 10–40	DN 50	2.4 (61)	0.97 (25)	1.31 (33)	5.65 (143)
DIN 2501 PN 25/40	DN 80	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	DN 100	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
DIN 2501 PN 10/16	DN 100	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)

(1) *Tolerances are 0.040 (1,02), –0.020 (0,51).*

3051H Pressure Transmitter Exploded View and Dimensional Drawings







Dimensions are in inches (millimeters)